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Donald E. Russell and Zhai Ren-jie

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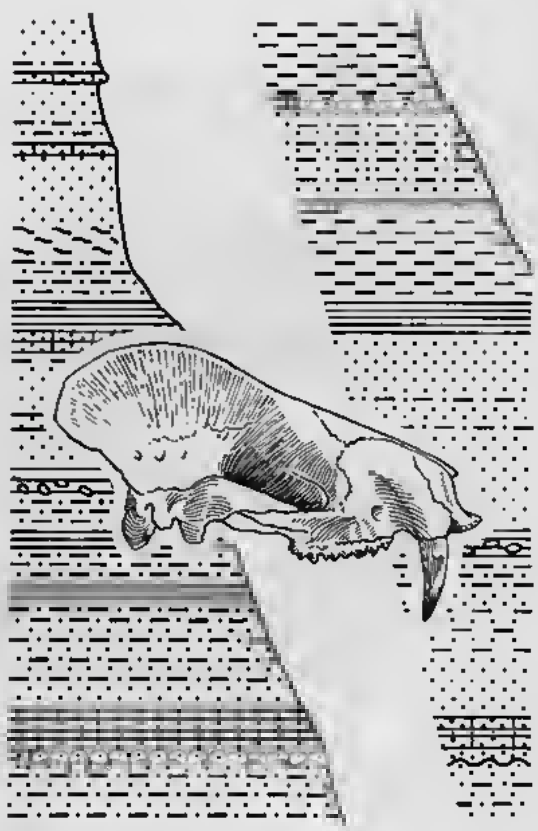

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TOME 52

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The Paleogene of Asia: mammals and stratigraphy

Publié avec le concours du Centre national de la Recherche scientifique

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Dedicated to

Professor Donald E. Savage, a great paleontologist, teacher and friend,

Professor Minchen Chow, an outstanding figure in paleontology to whom students of the Paleogene of China owe so much.

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RÉSUMÉ

RUSSELL D. E. & ZHAI R.-J., 1987.07.24. PALEOGENE OF ASIA : MAMMALS and STRATIGRAPHY. Mém. Mus. natn. Hist. nat., Paris, (Série C) 52 : 1-490. Paris. ISBN 2-85653-140-7.

Le Paléogène d'Asie : faunes mammaliennes et stratigraphie.

La connaissance des faunes du Paléogéne d'Asie a beaucoup souffert, dans le passé, du régionalisme, tant en Union Soviétique qu'en République Populaire de Chine, au point que les chercheurs de l'un de ces pays n'avaient qu'une idée assez vague des travaux réalisés dans l'autre. L'isolement était encore plus grand vis-à-vis des chercheurs occidentaux, la barriére linguistique et la dispersion des renseignements dans des publications souvent introuvables étant les principales responsables de cette situation. De plus, l'emplacement géographique de nombreux gisements ainsi que leur contenu faunistique et leur âge restaient souvent imprécis ou estimés sur des bases inexactes.

Les auteurs ont donc tenté, dans ce volume, de recenser les faunes mammaliennes, et ce pour le Paléogéne de tout le continent asiatique, en réactualisant les déterminations systématiques á la lumiére des progrés considérables réalisés par la paléontologie durant les derniéres décennies ; et en même temps de préciser leur cadre stratigraphique et sédimentologique.

On trouvera pas conséquent dans ce livre les listes fauniques complétes avec synonymes et références bibliographiques, la description détaillée des sédiments, la justification de l'âge attribué, qui s'est trouvé être revu et modifié pour un nombre considérable de formations géologiques : les sédiments paléogénes de Chine, ainsi que d'une grande partie de l'Asíe, sont en effet d'origine terrestre et les cas oú il est possible de les corréler avec les séries marines sont rarissimes. Or, par comparaison des faunes mammaliennes entre elles, les auteurs ont pu proposer un tableau de corrélations á l'échelle du continent. A partir de quoi il a été possible d'entreprendre la comparaison des faunes asiatiques avec celle d'Europe et d'Amérique du Nord, ce qui a permis de relier les séquences d'Asie avec celles de ces deux continents : les grandes régions de l'Hémisphére Nord sont désormais intégrées, pour le Paléogéne, dans un ensemble unique. Dés le Paléocéne tardif, on rencontre en effet des genres communs á l'Amérique et à la Chine. De même, au début de l'Eocéne, il existe un petit noyau de genres communs témoignant des liens de l'Asie avec l'Europe aussi bien qu'avec l'Amérique. A l'Eocéne moyen, le nombre de genres communs à ces trois continents atteint son maximum. Ces migrations se sont apparemment poursuivies jusque dans l'Oligocéne inférieur, á partir de quoi les ressemblances s'estompent.

Enfin l'ouvrage se termine par une proposition d'âges mammaliens asiatiques, c'est-à-dire de niveaux caractérisés par un ensemble d'espéces et comparables aux âges définis et utilisés comme repéres en Amérique du Nord et en Europe depuis une quarantaine d'années.

De nombreuses cartes et coupes lithostratigraphiques illustrent ce volume ; enfin un index paléontologique, géologique, et géographique aidera le lecteur à consulter celui-ci utilement.

Source : MNHN, Paris

ABSTRACT

RUSSELL D. E. & ZHAI R.-J., 1987.07.24. PALEOGENE OF ASIA : MAMMALS and STRATIGRAPHY. Mém. Mus. natn. Hist. nat., Paris, (Série C) 52 : 1-490. Paris. ISBN 2-85653-140-7.

Knowledge of the Paleogene faunas of Asia has greatly suffered in the past from regionalism, as much in the Soviet Union as in the People's Republic of China. This isolation was considerably aggravated with respect to scientists in the Western world; linguistic barriers and the dispersion of information in sometimes inaccessible publications were the principal causes of this problem. Moreover, the geographic situation of many localities, as well as their faunal contents or their age, remained inaccurate or estimated on faulty data.

The authors of this book have tried to list the mammalian assemblages known during the Paleogene for the entire continent of Asia. In the light of the substantial progress in paleontology that has occurred in recent decades, systematic determinations have been brought up to date. At the same time an attempt has been made to explain the stratigraphic and sedimentologic environment existing at each locality, and the reasons behind the age proposed for the beds and the fauna.

Consequently, in this book will be found complete faunal lists, with synonyms and bibliographic references, a detailed description of the sediments, and the justification of the age attributed. The latter endeavor has resulted in the modification of the supposed age of a considerable number of geologic formations; the Paleogene sediments of China, like those of a large part of the rest of Asia, are of terrestrial origin and the instances where it is possible to correlate with the marine series are extremely rare. In arriving at these modifications, first the elements of the mammalian faunas were compared and a correlation chart for the Asian continent constructed. From this base it was then possible to compare Asian faunas with those of Europe and North America, and to integrate them into the biostratigraphic scales established on these continents. The major regions of the northern hemisphere are now firmly linked for the Paleogene in a fairly uniform sequence of contemporaneous faunas.

As early as the late Paleocene it is possible to recognize common elements in the assemblages of china and North America. The same occurs during the early Eocene, where genera found on all three continents are known. Wioth the middle Eocene evidence of intercontinental faunal exchange reaches a maximum. These migrations continued into the early Oligocene, after which faunal resemblances decrease.

This volume ends with the proposal of a series of Land Mammal Ages for Asia, similar in concept to those already used in Europe and North America.

Many maps and lithostratigraphic sections illustrate the book, which concludes, as an aid to the the reader, with a geologic, geographic and systematic index.

Source : MNHN, Paris

INTRODUCTION

GENERALITIES

With respect to the enormous extent of the Asian landmass, the Paleogene is poorly represented and knowledge of its contents relatively slight. In the Soviet Union terrestrial fossils of this age are essentially restricted to the riches of the Kazakh S.S.R.; the rest, with rare exceptions in the Georgian S.S.R., the Far East Maritime Province and the Kirgiz S.S.R., is emptiness. Fossiliferous continental sediments are more widely distributed in the People's Republic of China, and the southern part of the Mongolian People's Republic has been highly productive. Recent field work (since the 1970's) in northwest India and northern Pakistan has revealed a fauna that is, in many ways, unusual in composition with respect to those of similar latitudes in China. Similar in barenness to most of the U.S.S.R., the south of Asia has also been surprisingly lacking in Paleogene mammals. Tropical faunas, as usual, elude us.

Before the discovery of Eocene mammals at Artëm, in the Far East Maritime Province, the oldest Tertiary mammalian fauna in the U.S.S.R. was that of the middle Oligocene Indricothere Beds of Kazakhstan. This strikingly underscores the fact that all early Paleogene sites in the Soviet Union are the result of post-1952 exploration. The Central Asiatic Expeditions of the American Museum of Natural History did exploratory work for five seasons (1922, 1923, 1925, 1928, 1930) in Inner and Outer Mongolia. The fossil collections and geologic studies that were made have formed the basis for much of our knowledge of the region today. Although Eocene and Oligocene localities were known in China south of the Gobi in the 1920's, very little augmentation of the collections occurred until approximately the 1960's, when increased field activity on the part of crews directed by Minchen Chow was responsible for much new material collected and described. The highly successful campaigns in the southern Gobi by Mongolian, Polish and Russian colleagues also date from early in the 1960's. The coming of age of Asian Paleogene paleontology is a modern phenomenon, essentially a product of the last 25 years. This is amply demonstrated by the comprehensive review of " Chinese Fossil Mammals " by Teilhard de Chardin & Leroy (1942), which is principally concerned with post-Paleogene forms.

" The Paleogene of Asia " began by Russell in 1975 as a survey of what could be extracted with relative ease from behind the language barriers of Russian and Chinese. It expanded in scope and optimism over the years but basically remained a fascinating pastime that occupied innumerable evenings and weekends. A vital breakthrough occurred in 1980 when Zhai R.-j. agreed to collaborate on the part concerning China. Two trips to the Soviet Union and help from workers familiar with Mongolia aided in accumulating necessary information on these major regions of paleontological interest. The rest filled in gradually, thanks in large part to many colleagues.

One of our principal preoccupations here has been the problem of correlation. A conscientious effort has been devoted to the reduction, if not elimination, of oracular pronouncements concerning the age of the faunal assemblages treated. In every case we have endeavored to give the reasons why the fauna of a given locality is considered to represent the age that is assigned to it. Often this can be based only on the stage of evolution of various elements, a notoriously uncertain procedure. However, given the general lack of marine-continental intercalations in Asia, one is obliged to be pragmatic and do the best possible with what is available. Intercontinental correlation by terrestrial mammals is treated in the conclusion.

The aim of our work was to present as clear a picture as we were able of the geographic and stratigraphic conditions of the fossil localities producing mammals; emphasis was put on maps and

Source : MNHN, Paris

geologic sections. Short historical accounts of discovery and exploitation, included when possible, were considered of interest and perhaps of some utility. A maximum of effort was applied to the faunal lists. But we declined the responsibility of adding the birds, reptiles, amphibians and fish that so frequently accompany mammalian remains; such an expansion of the scope would have been beyond our means as well as competence. If a biased view results, we trust we have nevertheless laid a foundation upon which other specialists may construct.

TECHNICALITIES

A wealth of the older bibliographic references and other information on the U.S.S.R. is to be found in Borisyak and Belyayeva's (1948) " Catalog of the the sites of Tertiary land mammals in the territory of the U.S.S.R. ". A diversified and useful account is available in the " Zoogeography of the Paleogene of Asia " (Flerov *et al.*, 1974), although its accessibility to Western scientists is also limited by the Russian text. A shorter review, but oriented more toward paleontological correlations, was published the same year by Belyayeva *et al.* in " Mesozoic and Cenozoic faunas and biostratigraphy of Mongolia ".

Nearly all the Chinese data are distributed through the last 25 years of Vertebrata Pal-Asiatica, an intriguing and often challenging source of information where an abstract in English is not always included (true also for most of the Soviet publications). Since so much of the Chinese paleontological literature has appeared in this one journal, we have added its initials, V.P., followed by the fascicle in parentheses, after the author and date of a species name for quick reference to the original article.

All the major western European languages have their own system for transliterating the Cyrillic alphabet; in perusing the older literature, and lists that derive from such a varied source, a bewildering array of names can result. With due regard to the contemporary epoch and to the fact that this is basically a paleontologic endeavor, we will follow the system used in the recent volumes of the " Bibliography of Fossil Vertebrates " (for example, Bacskai *et al.*, 1983).

As a minor aside, we have found that in Russian publications the terms basin and depression are frequently used interchangeably. We are, therefore, not always able to justify tectonically the presence of one or the other.

The hyphenation of place names is very erratically applied in the literature; multiple elements in a name can be found treated as separate words, or as hyphenated words, or combined as a single word. Given the variety of precedents one tends to feel free to make a choice, Following a practice that is rather general in the U.S.S.R. and in Mongolia, we have throughout our text for these countries hyphenated names composed of two or more words.

In matters of taxonomy concerning groups with which we were unfamiliar (for example, rodents), we have tried to reflect the opinion of a majority of specialists, or that of the latest reviewer.

The term Insectivora has been frequently criticized and its contents divided to various degrees. As used in our lists the concept corresponds to the Lipotyphla of recent specialists (except when quoted as " Insectivora indet. ", which could mean anything).

No convenient system exists in present classifications for indicating the authorship of genera. This has troubled us; in seeking to resolve the problem we have decided, however, only to indicate who caused (and when) a change in the generic designation of a species. In the interest of simplicity we have not distinguished between a new genus created for a certain species and referral to an already existing genus; both are represented by the name of the changer (and the date).

Example: *Minchenella grandis* (Zhang, 1978) Zhang, 1980
(= *Conolophus grandis* Zhang, 1978).

Minchenella is a new genus name created by Zhang, 1980, for the species *grandis* originally referred to *Conolophus* by Zhang, 1978.

Source : MNHN, Paris

We place the question mark (?) after the name questioned; in *Phyllotillon? betpakdalensis*, the generic designation is doubted.

On many maps and sections capital letters with numerical appendages, both above and below, are to be found. For those not familiar with this system of indicating ages a short explanation is perhaps warranted. E (or Pg) = Paleogene; N = Neogene; E_1 = Paleocene; E_2 = Eocene; E_3 = Oligocene. E_1^1 = early Paleocene; E_1^2 = middle Paleocene; E_1^3 = late Paleocene (E_2^3 = late Eocene; E_3^2 = middle Oligocene). Sometimes rock units are indicated, as in $E_1^{D\text{-}2}$: D in this example stands for the Doumu Formation; the 2 means its upper (or second) part. A similar way of transmitting information can be found in $E_2^{3\text{-}1}$ in which the final top 1 modifies the 3 to indicate the lower part of the late Eocene.

We retain the Russian term svita in our text in referring to strata in the Soviet Union and Mongolia. Two concepts are however used by Soviet geologists to subdivise geologic deposits — svita and formation. In contrast to the svita, a formation is usually considered as a paragenetic association of rocks laid down during a definite geotectonic episode. A svita, according to the Stratigraphic Code of the U.S.S.R. (1977), occupies a determined place in a section and is characterized by specific facies-lithological and paleontological features. Svita is the preferred term of Soviet geologists. It must be emphasized that it should not be translated loosely to mean formation: one of the distinguishing features of a svita is that its upper and lower boundaries are considered to be isochronous, thus making it a temporal term and not exclusively a lithostratigraphic unit. Holland (1983) suggests using the English informal term " bed " in translating svita. Underlining the difference in concepts, he cogently adds " it is perhaps also true to say that Soviet stratigraphers may be more inclined to the view that stratigraphy is ' all one ', so that too rigid a discrimination between chronostratigraphy, biostratigraphy, and lithostratigraphy is thought to be mistaken ".

In subdividing a svita, the practice in the Soviet Union is not to refer to, for example, the lower Aksyir Svita as such, but to render the concept as *nizhneaksyirskaya podsvita*. The terms lower, middle and upper are incorporated in the form of *nizhne-*, *sredne-* and *verkhne*, respectively, with *podsvita* indicating subsvita.

For economy of space certain countries will be referred to in the text by shortened denominations, as follows:

Burma — Socialist Republic of the Union of Burma
China — People's Republic of China
India — Federal Republic of India
Indonesia — Republic of Indonesia
Mongolia — Mongolian People's Republic
North Korea — Democratic People's Republic of Korea
Pakistan — Republic of Pakistan
U.S.S.R. — Union of Soviet Socialist Republics.

The translation of local names that has been added in footnotes is to permit a glimpse of the folklore that is behind, for many of us, unintelligible words.

This compilation was intended for the working paleontologist, that is, for those doing the basic research on faunal constituents; the theoretician has no need for the authors and dates of species and little for synonymy. The elementary need is for field work. Fewer hypotheses would be necessary if we had more fossils.

Source : MNHN, Paris

Source : MNHN, Paris

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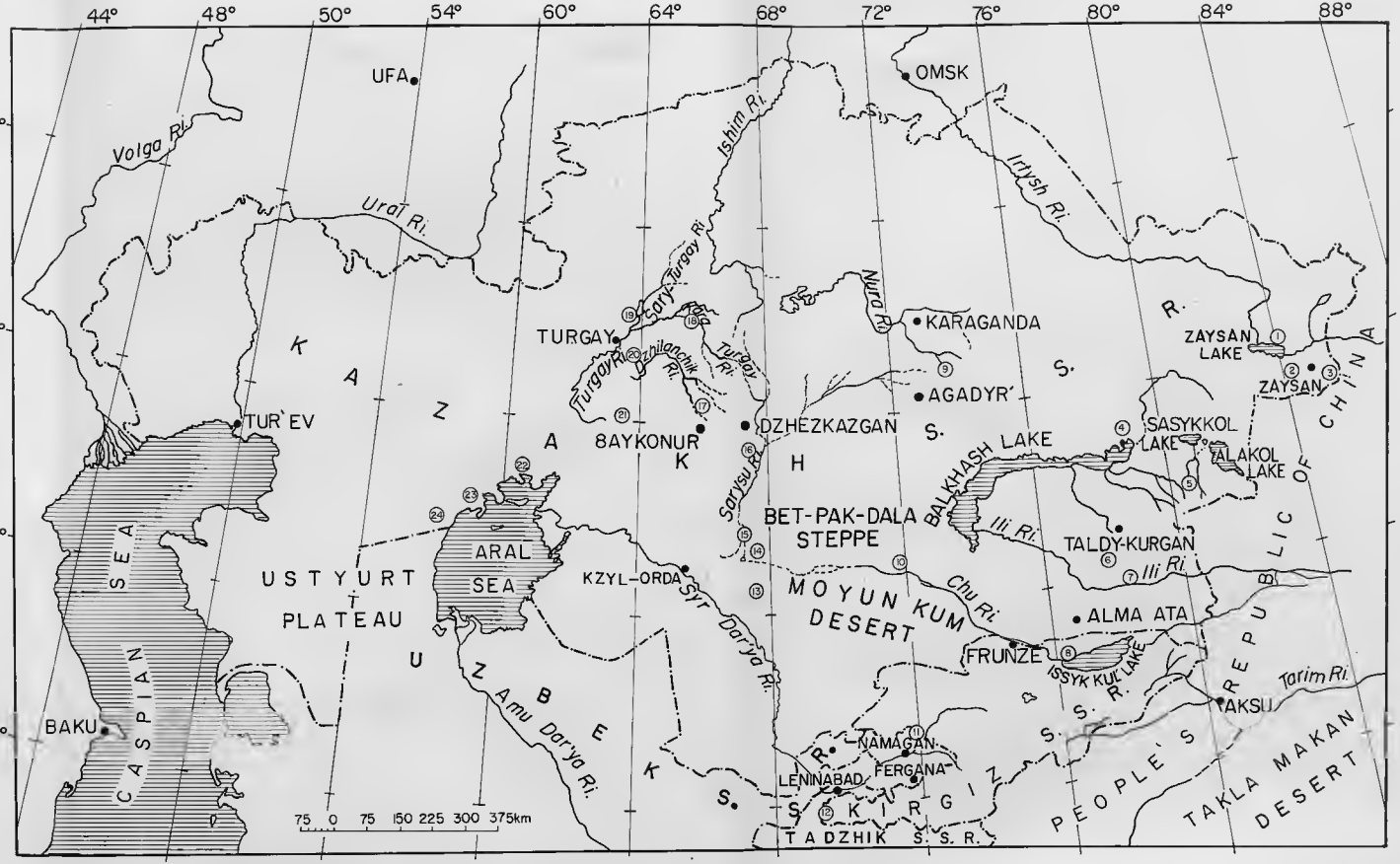

FIG. 3. — Principal Paleogene localities of the Kazakh S.S.R. and the Kirgiz S.S.R. **1.** Zaysan areal site VI; **2.** Zaysan areal sites IV, VIII, X; **3.** Zaysan areal sites I, II, III, V, IX, XI; **4.** Sary-Ozek River; **5.** Shinzhaly; **6.** Sary-Ozek Station; **7.** Aktau; **8.** Toru-Aygyr; **9.** Aksoran; **10.** Saroy; **11.** Mayli-Say; **12.** Andarak; **13.** Kara-Tau; **14.** Askazan-Sor; **15.** Sary-Su; **16.** Kyzyl-Kak; **17.** Myneske-Suyek; **18.** Alua; **19.** Mogila-Saty; **20.** Shintuz-Say; **21.** Chelkar-Teniz; **22.** Agyspe; **23.** Sayaken; **24.** Zhilansay and Kuzhasay.

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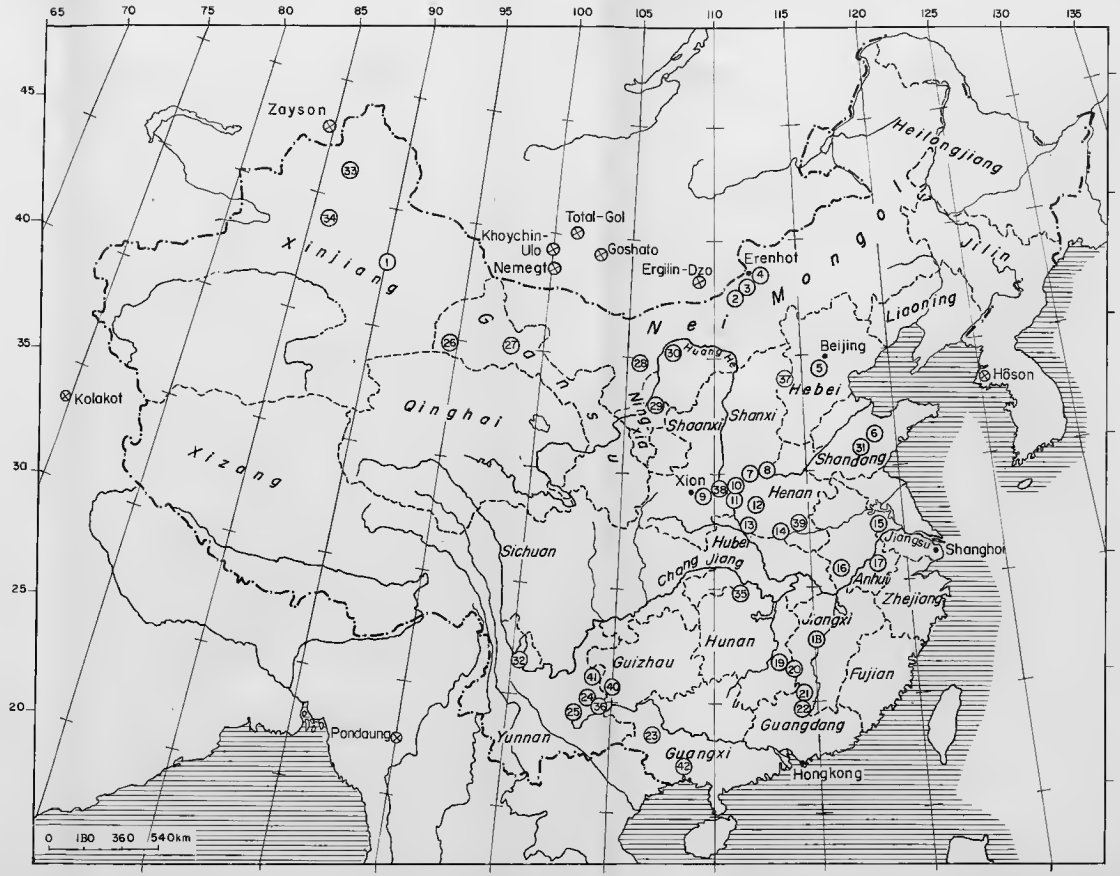

FIG. 2. — Principal Paleogene localities of China. **1**. Turpan Basin; **2**. Shara Murun Region; **3**. Nomogen Region; **4**. Sunid Zuoqi (Arshanto); **5**. Changxindian; **6**. Changle and Linqu Districts; **7**. Yuanqu Basin; **8**. Jiyuan Basin; **9**. Lantian District; **10**. Lingbao Basin; **11**. Lushi Basin; **12**. Tantou Basin; **13**. Xichuan Basin; **14**. Wucheng Basin; **15**. Laian District; **16**. Qianshan Basin; **17**. Xuancheng Basin; **18**. Yuanshui Basin; **19**. Hengyang Basin; **20**. Chaling Basin; **21** Chijiang Basin; **22**. Nanxiong Basin; **23**. Bose and Yongle Basins; **24**. Yuezhou Basin; **25**. Lunan Basin; **26**. Taben Buluk and Yindirte; **27**. Hui-hui-p'u area; **28**. Haosibuerdu Basin; **29**. Lingwi District; **30**. Qianlishan District; **31**. Xintai District; **32**. Lijiang Basin; **33**. North part of Junggar Basin; **34**. South part of Junggar Basin; **35**. Yidu District; **36**. Luoping Basin; **37**. Quyang District; **38**. Shimen Basin; **39**. Pingchangguan Basin; **40**. Shinao Basin; **41**. Xuanwei Basin; **42**. Nanning Basin.

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Source : MNHN, Paris

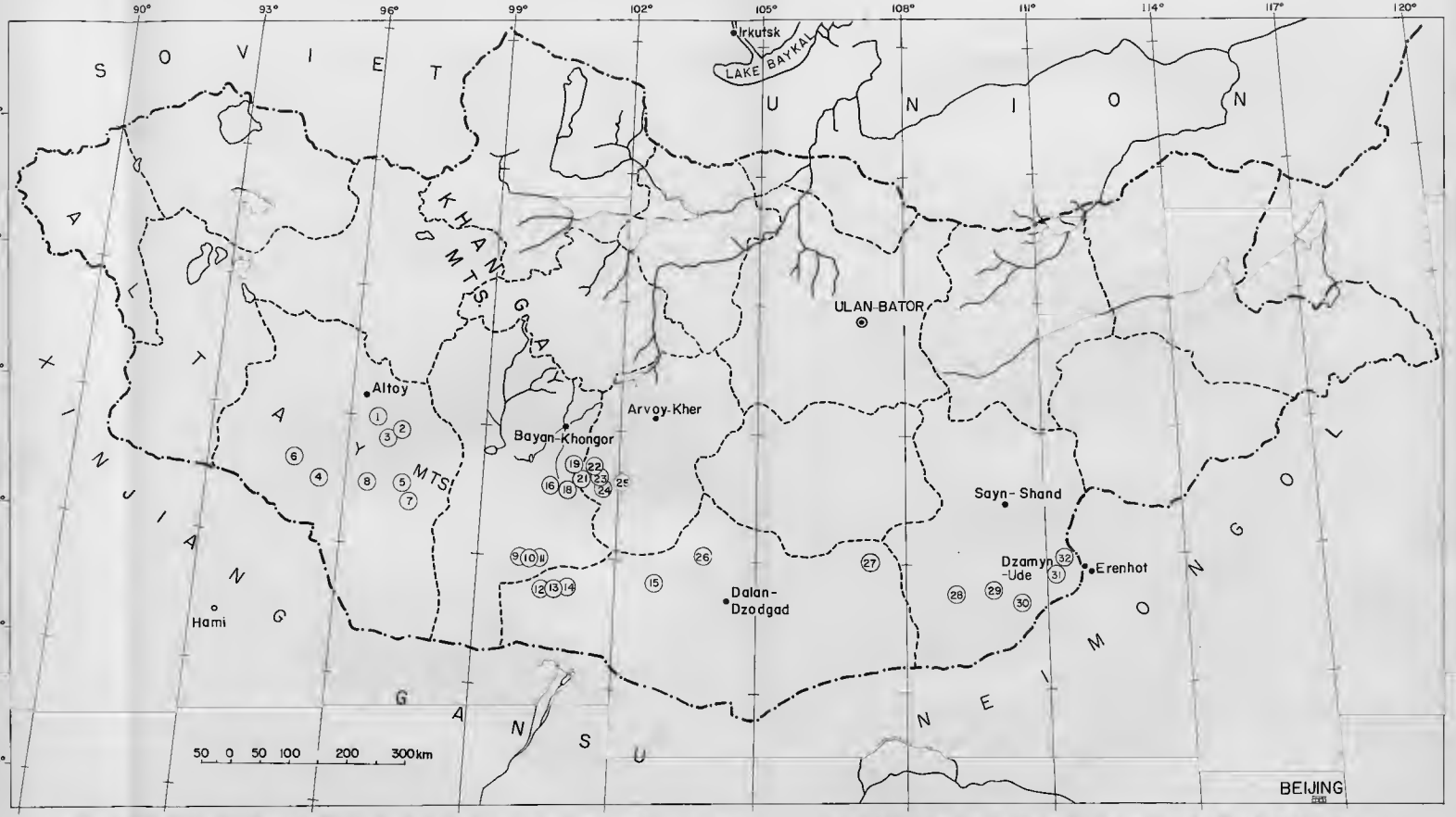


FIG. 1. — Principal Paleogene localities of Mongolia. Base map modified from the Times Atlas of the World, 1974. **1**. Shineh-Us; **2**. Beger; **3**. Khalyun; **4**. Bungin-Gol; **5**. Narin-Bulak; **6**. Khaytch; **7**. Ulan-Ganga; **8**. Khatan-Khayrkhan; **9**. Khaychin-Ula 1; **10**. Khaychin-Ula 2-3; **11**. Khaychin-Ula 5; **12**. Tsagan-Khushu and Ulan-Khureh; **13**. Naran-Bulak; **14**. Ulan Bulak; **15**. Tsakhir; **16**. Barun Khutsyn Tsav; **18**. Tsagan Khutel; **19**. Menkhen Teg; **21**. Tsagan-Obo; **22**. Buil'stiyn-Khuduk; **23**. Tatal-Gol; **24**. Shand-Gol; **25**. Ikh-Argalantu-Nuru; **26**. Gashato; **27**. Shunkhu; **28**. Ergilin-Dzo; **29**. Gua-Teg; **30**. Alag-Tsav; **31**. Khoer-Dzan; **32**. Mergen.

Source : MNHN, Paris

Lat. 44° N, approx.
Long. 100° E, approx.

Fig. 1, n° 9

MONGOLIA
ZAALTAY GOBI PROVINCE
Bugin-Tsav Basin

Dzunmod Svita **late Cretaceous**
Locality: Khaychin-Ula 1

It is not our intention to deal with Cretaceous mammal localities here, but the site called Khaychin-Ula 1 is often cited as being Paleocene in age. For this reason it is discussed.

Fossils were found in the Bugin-Tsav [1] area by Mongolian shepherds. The fact was reported in 1964 to the Academy of Sciences of the Mongolian People's Republic in Ulan-Bator [2], which sent a paleontological expedition to the region in the same year; dinosaurs were collected. In 1968, the geologist Sochava, a member of the Soviet-Mongolian Geological Expedition, discovered an incomplete multituberculate skull in the Bugin-Tsav badlands that was described and named *Buginbaatar transaltaiensis* by Kielan-Jaworowska and Sochava in 1969. The lower jaw of the specimen was described by Trofimov in 1975.

The locality, named Khaychin-Ula I [3] by Reshetov during field work in the region of Khaychin-Ula, was geologically described by Shuvalov, Reshetov and Barsbold, 1974. The beds containing the multituberculate specimen, the Dzun-

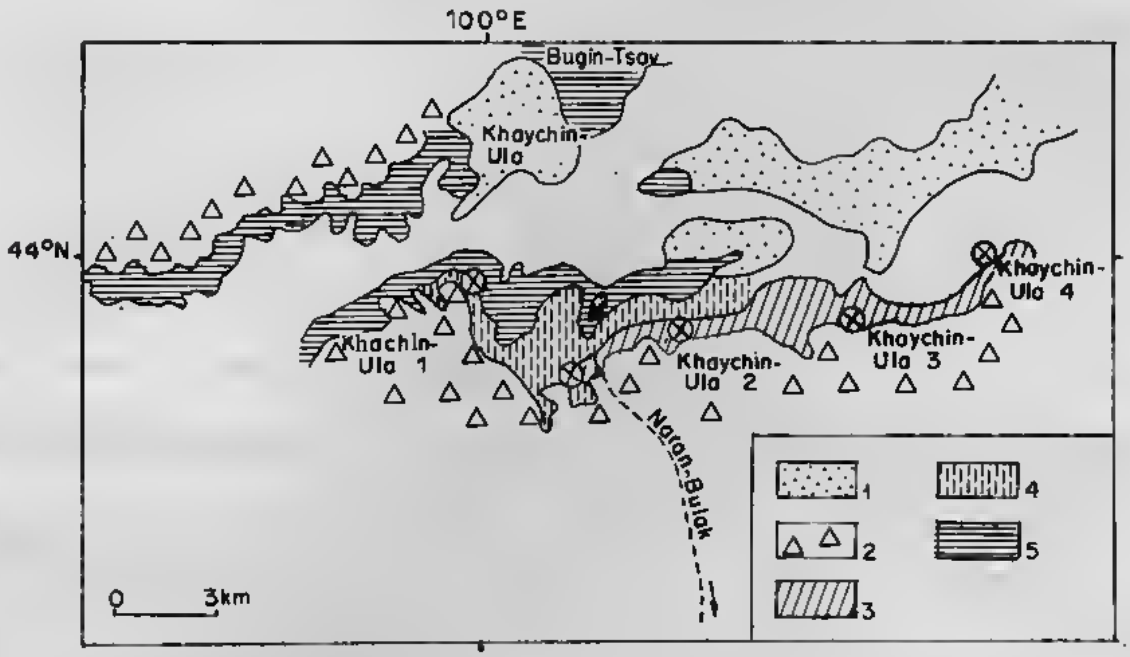


FIG. 4 — Geologic sketch map of the Khaychin-Ula region. **1.** eolian sand; **2.** alluvium; 3. outcrops of the Khaychin Svita; **4.** outcrops of the combined Dzunmod and Naran-Bulak Svitas; **5.** outcrops of the Nemegtskaya Svita. Modified from Devyatkin, 1981.

1 Bugin-Tsav = evil spirit cliff.
2 Ulan-Bator = red hero.
3 Khaychin-Ula = scissors mountain. Khaychin = literally scissors, but more probably referring to a sharp mountain that "cuts" or separates one region from another. Ula = large hill or mountain.

Source : MNHN, Paris

mod [4] Svita, consist of 20 m of sediments: light gray, weakly cemented, well sorted sandstones, with stringers of denser sandstones; higher in the section the stringers increase in number and beds of greenish gray and reddish buff clays appear. The upper limit of the Dzunmod Svita is drawn at the top of the latter. The Dzunmod Svita overlies the late Cretaceous Nemegt Svita and is itself overlain by Pleistocene conglomerates.

The age of the beds was uncertain for nearly 20 years; most indications suggested affinity to the late Cretaceous, but the relatively advanced evolutionary stage of the multituberculate, in particular, provided a serious argument for considering them early Paleocene. Gradzinski *et al.* (1968/1969), Kielan-Jaworowska and Sochava (1969), Belyayeva *et al.* (1974) and Flerov *et al.* (1974), all conditionaly referred the beds bearing *Buginbaatar* to the late Cretaceous, while not excluding the possibility of a Paleocene age for them; Shuvalov, Reshetov and Barsbold (1974), Trofimov (1975) and Badamgarav and Reshetov (1976) tended to view them as more probably Paleocene, but also admitted an element of doubt. All dissension was effectively stilled with the subsequent discovery of several dinosaurs in the same level that furnished *Buginbaatar* (Reshetov, pers. com., 1981); it is Cretaceous.

Mammalian fauna of the Dzunmod Svita

MULTITUBERCULATA
EUCOSMODONTIDAE — *Buginbaatar transaltaiensis* Kielan-Jaworowska & Sochava, 1969.

Lat. 30° 35′ - 30° 45′ N
Long. 116° 28′-116° 38′ E
(Qianshan City: 30° 36′ N, 116° 36′ E)

Fig. 2, n° 16

CHINA
ANHUI PROVINCE
Qianshan Basin

Wanghudun Formation **early? — middle Paleocene**

In the vast area of southern China there are many intermontane basins filled with Cretaceous or Tertiary clastic sediments of considerable thickness. These deposits are mostly reddish in colour, rather uniform in lithological character, and rarely produce fossils. Taking part in a research program of the IVPP, aimed at shedding light on the age and fossil content of these red beds, a prospecting crew discovered Paleocene fossils in the Qianshan Basin in 1972. Field work continued during the following years and is still actively pursued.

The Qianshan [5] Basin lies north of the Changjiang (Yangtze) River in Qianshan and Huaining Counties, southern Anhui Province. The Paleocene rocks, overlying Cretaceous red beds (Wanghe [6] Formation), are extensively developed and have been divided into an upper Doumu [7] Formation and a lower Wanghudun [8] formation.

The Wanghudun Formation, about 1,800 m in

4 Dzunmod = one hundred trees.
5 Qianshan (= Chienshan) = concealed mountain.
6 Wanghe = Wang (family name) River.
7 Doumu (= Toumu) = goddess of smallpox.
8 Wanghudun (= Wanghutun) = a mound from which a man kept watch over a tiger.

Source : MNHN, Paris

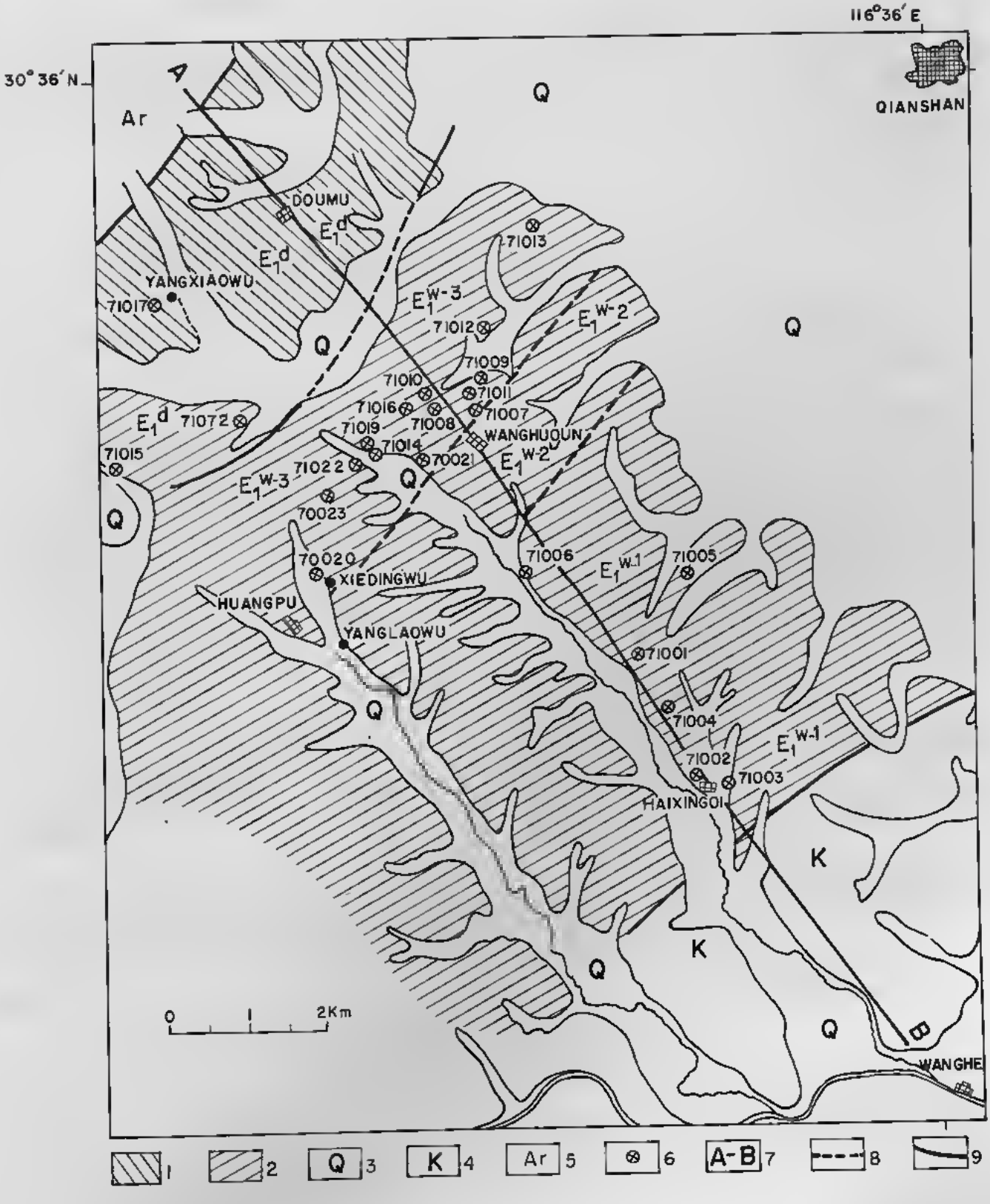


FIG. 5. — Fossil mammal locality map of the Qianshan District, Anhui. 1. Doumu Fm.; 2. Wanghudun Fm.; 3. Quaternary; 4. late Cretaceous Wanghe Fm.; 5. Archaeozoic; 6. fossil mammal locality; 7. section line; 8. supposed limit between formations or between members of the Wanghudun Fm.; 9. limit between formations. Modified from Qiu *et al.*, 1977.

Source : MNHN, Paris

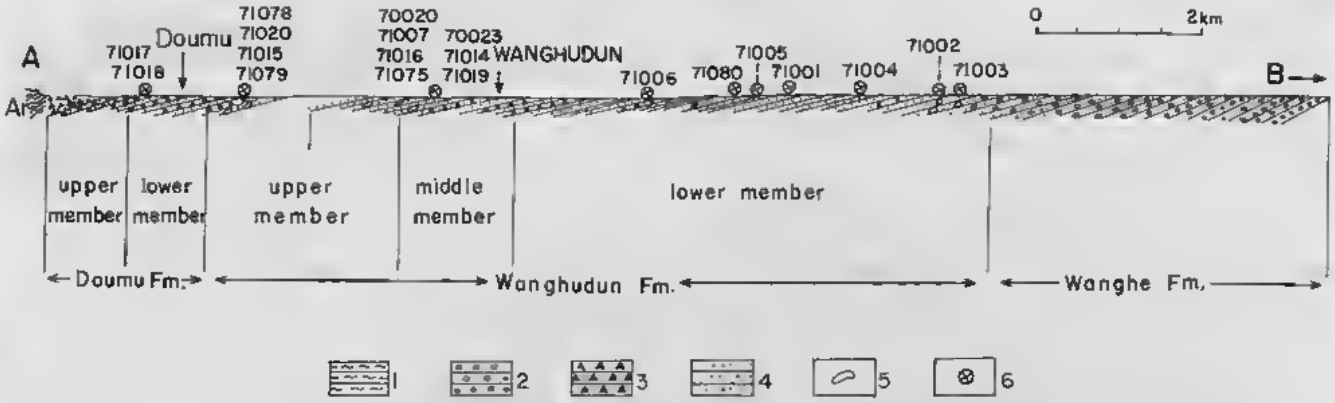


FIG. 6. — Cross section taken between Doumu and Wanghe, Qianshan Basin, Anhui. 1. Precambrian metamorphic rocks; 2. conglomerate; 3. breccia; 4. sandstone; 5. concretions; 6. fossil mammal locality. Modified from Qiu *et al.*, 1977.

thickness, is divided into three members and differs from equivalent sediments in Guangdong and Jiangxi by being coarser grained. The lower member consists of purplish red marly sandstone with intercalating conglomerates and sandstones; the upper member is predominantly purplish and brownish red sandstones with intercalating grayish white sandstones. No fossils have been found in the middle member.

The age of the Wanghudun Formation is indicated by the presence of bemalambdids, which never occur in overlying beds regarded as late Paleocene. For the present, this formation is not further subdivided in age; both fossiliferous levels will be considered as representing the early?-middle Paleocene. Despite suggestions to the contrary, there is as yet no definite evidence for an early Paleocene age of the lower part of the Wanghudun Formation.

Fauna of the Wanghudun Fm. (upper part)

PANTODONTA

HARPYODIDAE
— *Harpyodus euros* Qiu & Li, 1977, V.P. (2)

PASTORALODONTIDAE
— *Altilambda pactus* Chow & Wang, 1978, V.P. (2)
— *Altilambda tenuis* Chow & Wang, 1978, V.P. (2)

ANAGALIDA

ANAGALIDAE
— *Huaiyangale chianshanensis* Xu, Q., 1976a, V.P. (3)
— *Huaiyangale* sp.; cited by Xu, Q., 1976a, V.P. (3)
— *Diacronus anhuiensis* Xu, Q., 1976b, V.P. (4)
— *Diacronus wanghuensis* Xu, Q., 1976b, V.P. (4)

PSEUDICTOPIDAE
— *Anictops tabiepedis* Qiu, 1977
— *Anictops* aff. *tabiepedis* Qiu, 1977; cited by Qiu, 1977
— *Paranictops majuscula*, Qiu, 1977
— *Paranictops*? sp.; cited by Qiu, 1977

MIXODONTIA

EURYMYLIDAE
— *Heomys* sp.; cited by Li, 1977, V.P. (2)

MIMOTONIDAE
— *Mimotona wana* Li, 1977, V.P. (2)
— *Mimotona* sp.; cited by Li, 1977, V.P. (2)

CARNIVORA

VIVERRAVIDAE[9]
— *Pappictidops orientalis* Qiu & Li, 1977, V.P. (2)

9 Placed in this family by Gingerich and Winkler, 1985.

Source : MNHN, Paris

CONDYLARTHRA
HYOPSODONTIDAE — *Decoredon elongetus* Xu, 1977a, V.P. (2)
ORDER INDET [10]
DIDYMOCONIDAE? — *Zeuctherium niteles* Tang & Yan, 1976, V.P. (2)
FAMILY INDET. — *Obtususdon hanhuaensis* Xu, 1977a, V.P. (2)

Fauna of Wanghudun Fm. (lower part)

PANTODONTA
BEMALAMBDIDAE — *Bemalambda* sp.; cited by Qiu *et al.*, 1977, V.P. (2)
— genus and species indet.; cited by Huang, 1978, V.P. (4)

ANAGALIDA
ANAGALIDAE — *Wanogale hodungensis* Xu, Q., 1976b, V.P. (4)
— *Chianshania qianghuaiensis* Xu, Q., 1976b
(= *Chianshania anhuiensis* Xu, 1976; cited erroneously by Qiu *et al.*, 1977, V.P. (2)
(PRIMATES? in Tong, 1979) — *Anaptogale wanghoensis* Xu, Q., 1976b, V.P. (4)
PSEUDICTOPIDAE — *Anictops tabiepedis* Qiu, 1977
— *Carnictops canina* Ding & Tong, 1979, V.P. (2)
(= *Paranictops* sp.; cited by Qiu, 1977)
(= Order and family uncert., gen, et sp. indet.; cited by Qiu & Li, 1977, V.P. (2))
(= Anagalidae, gen, et sp. indet.; cited by Ding et Tong, 1979, ibid.)
ASTIGALIDAE — *Astigale wanensis* Zhang & Tong, 1981, V.P. (2)

CONDYLARTHRA
MESONYCHIDAE — *Yantanglestes conexus* (Yan & Tang, 1976) Ideker & Yan, 1980, V.P. (2)
(= *Lestes conexus* Yan & Tang, 1976, V.P. (4))
(= *Notodissacus orientalis* Yan & Tang, 1976, V.P. (4) in list p. 93, and cited by Qiu *et al.*, 1977, V.P. (2), p. 86; *nomen nudum*)

ORDER INDET.
ZALAMBDALESTIDAE — *Anchilestes impolitus* Qiu & Li, 1977, V.P. (2)

Lat. 25° 00′ - 25° 10′ N
Long. 114° 15′-114° 30′ E
(Nanxiong City: 25° 07′ N, 114° 18′ E)

Fig. 2, n° 22

CHINA
GUANGDONG PROVINCE
(Kwangtung)
Nanxiong Basin

Shanghu Formation **early? — middle Paleocene**

In the north of Guangdong Province, the Nanxiong [11] Basin is located just south of the eastern part of the Nanling [12] Range at the foot of the southern slope of Dayu Mountain. It is in

10 = Condylarthra, Didymoconidae (?), *incertae sedis*, in Gingerich 1981.
11 Nanxiong (= Nanshiung) = southern hero.
12 Nanling = southern mountain.

Source : MNHN, Paris

the red beds of this basin that Paleocene mammals were discovered for the first time in South China. Inspired initially by a fortuitous find of fossil vertebrates by a regional mapping crew in 1961, the IVPP has repeatedly sent field parties into the region, gradually expanding their investigations to other basins also characterized by red beds. A symposium was held in Nanxiong in 1976, which resulted in the publication (in 1979) of a large memoir on "The Mesozoic and Cenozoic Redbeds of South China".

The Nanxiong Basin is about 80 km long and less than 20 km wide, elongated in a NE-SW direction and bounded by faults which separate the granitic ridges to the north from the basin rocks. The latter are a series of fine to medium

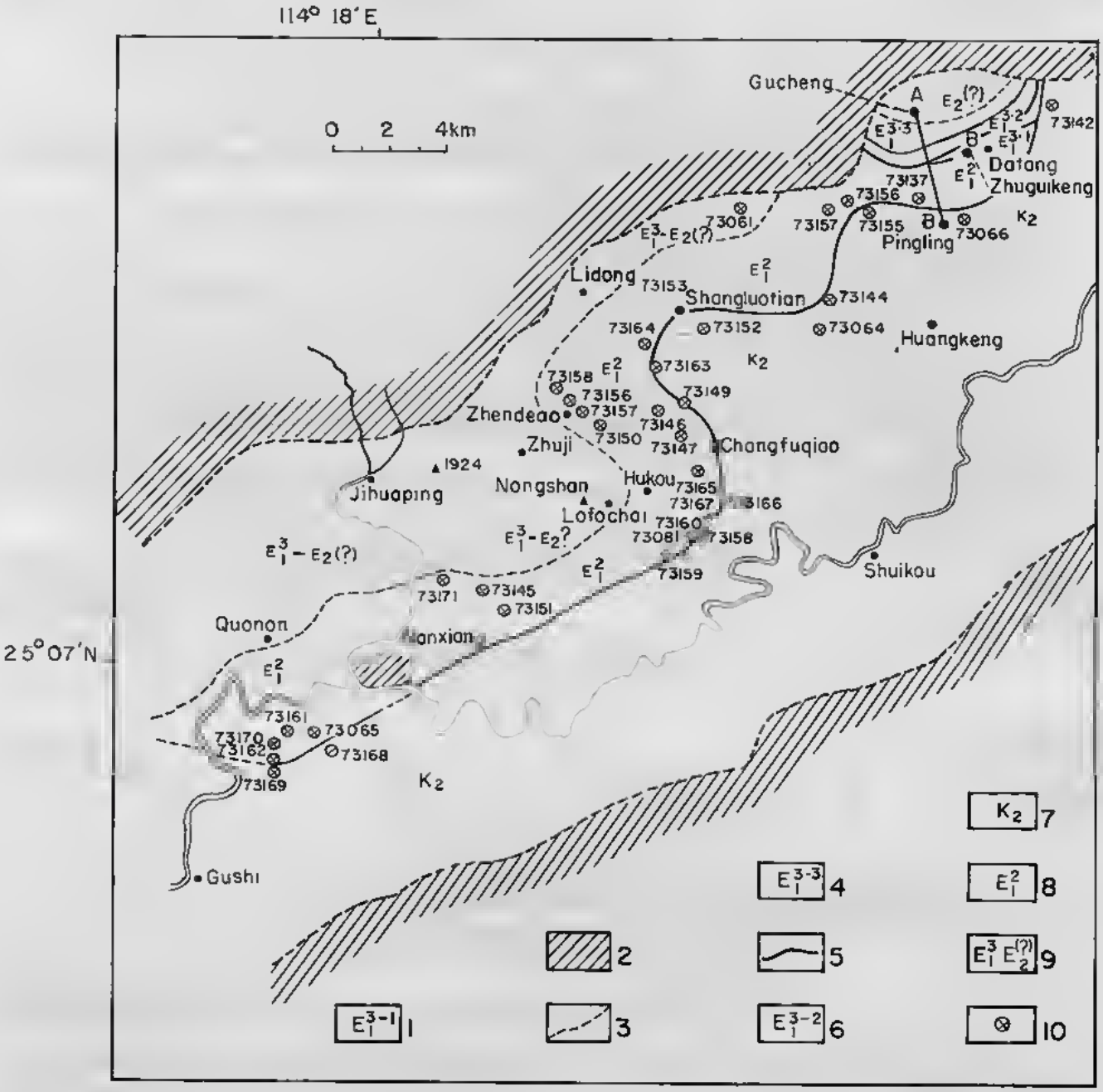


FIG. 7. — Map of the Nanxiong Basin, Guangdong, showing fossil mammal localities. 1. Zhuguikeng Member of the Nongshan Fm.; 2. old rocks; 3. supposed stratigraphic boundary; 4. unnamed member of the Nongshan Fm.; 5. stratigraphic boundary; 6. Dalang Member of the Nongshan Fm.; 7. late Cretaceous Nanxiong Fm.; 8. Shanghu Fm.; 9. Nongshan-Danxia Formations; 10. fossil vertebrate locality. Modified from Tong *et al.*, 1976.

Source : MNHN, Paris

grained detritals of piedmont and fluviatile origin deposited on an eroded granitic basement. The stratigraphic sequence (see Chang and Tung, 1963; Cheng *et al.*, 1973) in descending order is as follows:

The Danxia [13] Formation is a series of conglomerates and coarse grained sandstone of uncertain age (Eocene?), with a thickness of 100-550 m; it overlies the Paleocene rocks.

The Lofochai Group (originally called the Lofochai Formation) is made up of the Nongshan [14] Formation (late Paleocene) and the underlying Shanghu [15] Formation. The latter has a thickness that varies from 470-600 m, and consists mainly of purplish red mudstones with intercalating sandstones and conglomerates; oolitic concretions are present locally,

The late Cretaceous Nanxiong Formation

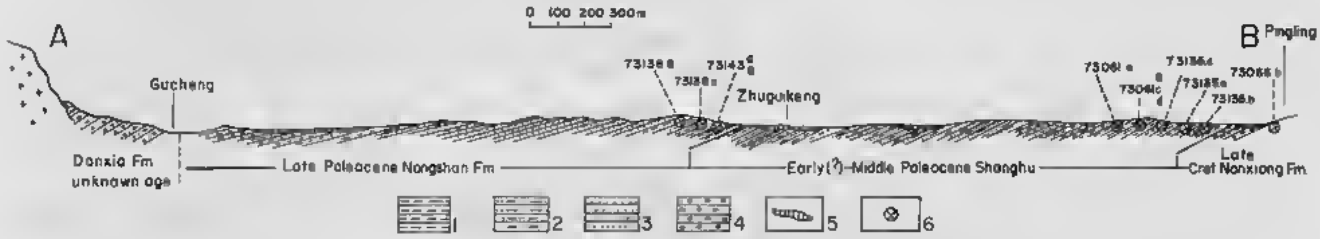


FIG. 8. — Cross section taken between Gucheng and Pingling, Nanxiong Basin, Guangdong. **1**. mudstone; **2**. argillaceous sandstone; **3**. sandstone; **4**. conglomerate; **5**. Recent covering; **6**. fossil mammal locality. Modified from Tong *et al.*, 1976.

underlies the Lofochai Group and its highest bone-bearing bed is only about one meter below the lowest mammal-bearing Paleocene level; there is no discernible structural or lithologic means of demarcation between it and the Paleocene beds.

The Shanghu Formation, like the nearby (and supposedly of similar age) Shizikou Formation in the Chijiang Basin, is typified by the presence of bemalambdids and by the absence of more advanced pantodonts. Agreement on the subdivision of the Shanghu Formation has not yet been reached; we have grouped together the mammalian assemblages formerly placed in a " lower " or " upper " part of the formation, since, faunally, there is no justification for such a division. Consequently, it cannot yet be demonstrated that the formation extends into the early Paleocene.

Fauna of the Shanghu Formation

PANTODONTA

BEMALAMBDIDAE
- — *Bemalambda nanhsiungensis* Chow *et al.*, 1973, V.P. (1)
- — *Bemalambda pachyoesteus* Chow *et al.*, 1973, V.P. (1)
- — *Bemalambda crassa* Chow *et al.*, 1973, V.P. (1)
- — *Bemalambda* sp.; cited by Zhou *et al.*, 1977

TILLODONTIA [16]

TILLOTHERIIDAE
- — *Lofochaius brachyodus* Chow *et al.*, 1973, V.P. (1)

TILLODONTIA?

FAMILY Inc. Sed.
- — *Dysnoetodon minuta* Zhang, 1980, V.P. (2)

ANAGALIDA

ANAGALIDAE
- — *Linnania lofoensis* Chow *et al.*, 1973, V.P. (1)

ASTIGALIDAE
- — *Astigale nanxiongensis* Zhang & Tong, 1981, V.P. (2)
- — *Zhujegale lirenensis* Zhang & Tong, 1981, V.P. (2)
- — *Zhujegale jintangensis* Zhang & Tong, 1981, V.P. (2)

13 Danxia (= Tanya, Oanya or Tanhsia) = red rosy cloud.
14 Nongshan = dark mountain.
15 Shanghu = upper lake.
16 Referred to the Pantodonta by Chow & Wang, 1979; denied by Lucas, 1982.

Source : MNHN, Paris

CARNIVORA

VIVERRAVIDAE
— *Pappictidops acies* Wang, B., 1978, V.P. (2)
— *Pappictidops obtusus* Wang, B., 1978, V.P. (2)

CONDYLARTHRA

PERIPTYCHIDAE
— *Ectoconus*? sp.; cited by Zhou *et al.*, 1977

HYOPSODONTIDAE
— *Yuodon protoselenoides* Chow *et al.*, 1973, V.P. (1)
— *Palasiodon siurenensis* (Chow *et al.*, 1973) Chow *et al.*, 1977
(= *Promioclaenus siurenensis* Chow *et al.*, 1973, V.P. (1)

MESONYCHIDAE
— *Dissacusium shanghoensis* (Chow *et al.*, 1973) Zhou *et al.*, 1977
(= *Dissacus? shanghoensis* Chow *et al.*, 1973, V.P. (1))
— *Hukoutherium ambigum* Chow *et al.*, 1973, V.P. (1)
— *Yantanglestes feiganensis* (Chow *et al.*, 1973) Ideker & Yan, 1980, V.P. (4)
(= *Lestes feiganensis* (Chow *et al.*, 1973) Yan & Tang, 1976, V.P. (4))
(= *Dissacus? feiganensis* Chow *et al.*, 1973, V.P. (1)
(= *Dissacus feiganensis* Chow *et al.*, 1973; cited by Zhou *et al.*, 1977 (written in 1973))

Lat. 25° 23′ - 25° 40′ N
Long. 114° 20′-114° 45′ E
(Chijiang Town: 25° 29′ N, 114° 34′ E)

Fig. 2, n° 21

CHINA
JIANGXI PROVINCE
(KIANGSI)
Chijiang Basin

Shizikou Formation **early? — middle Paleocene**

Chijiang Basin, in the southern part of Jiangxi Province, is situated on the northern flank of the Nanling Range, about 400 km north of the Nanxiong Basin. It is bounded to the north by a major fault that has elevated Paleozoic sediments into a high range of mountains.

Following the plan made by the IVPP to extend their prospecting to all of the regions in South China where red beds were exposed, an exploration crew entered the Chijiang Basin in 1972 and was rewarded by the discovery of early Tertiary mammals.

The Paleocene sediments in this basin have been grouped into an upper Chijiang [17] Formation, and a lower Shizikou [18] Formation. The latter, about 120 m thick, is mainly composed of beds of brick red sandy mudstone, mudstone, and grayish green sandstones. It rests disconformably on late Cretaceous red beds.

The fauna of the Shizikou Formation, practically restricted to bemalambdid pantodonts, correlates well with the Shanghu Formation of the Nanxiong Basin and the Wanghudun Formation of the Qianshan Basin. The reasoning on which its age determination is based is dependant on these other faunas.

17 Chijiang (= Chihkiang).
18 Shizikou (= Shihzekou) = lion's mouth.

Source : MNHN, Paris

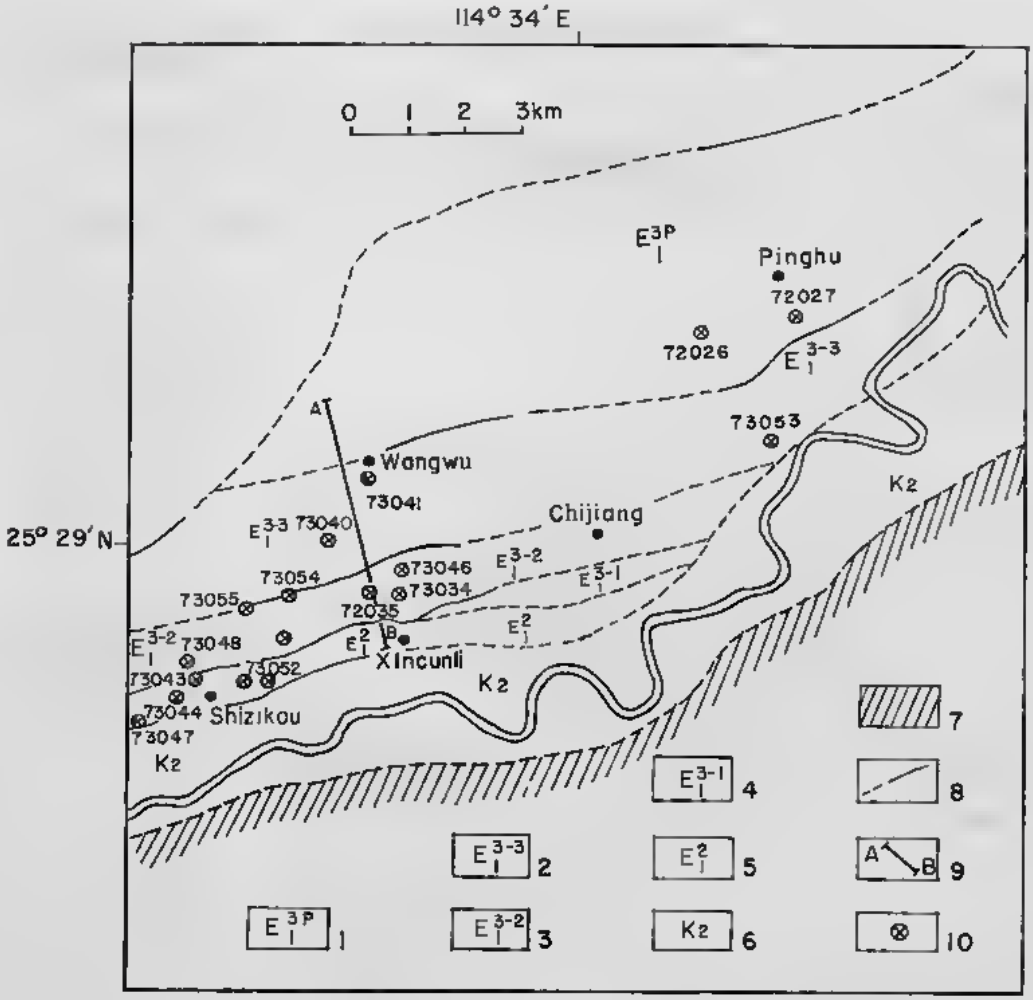


FIG. 9. — Map of the Chijiang Basin, Jiangxi. **1.** Pinghu Fm.; **2.** Wangwu Member of the Chijiang Fm.; **3.** Lannikeng Member of the Chijiang Fm.; **4.** unnamed member of the Chijiang Fm.; **5.** Shizikou Fm.; **6.** late Cretaceous Nanxiong Fm.; **7.** old rocks; **8.** stratigraphical boundary; **9.** section line; **10.** fossil mammal locality. Modified from Tong *et al.*, 1976.

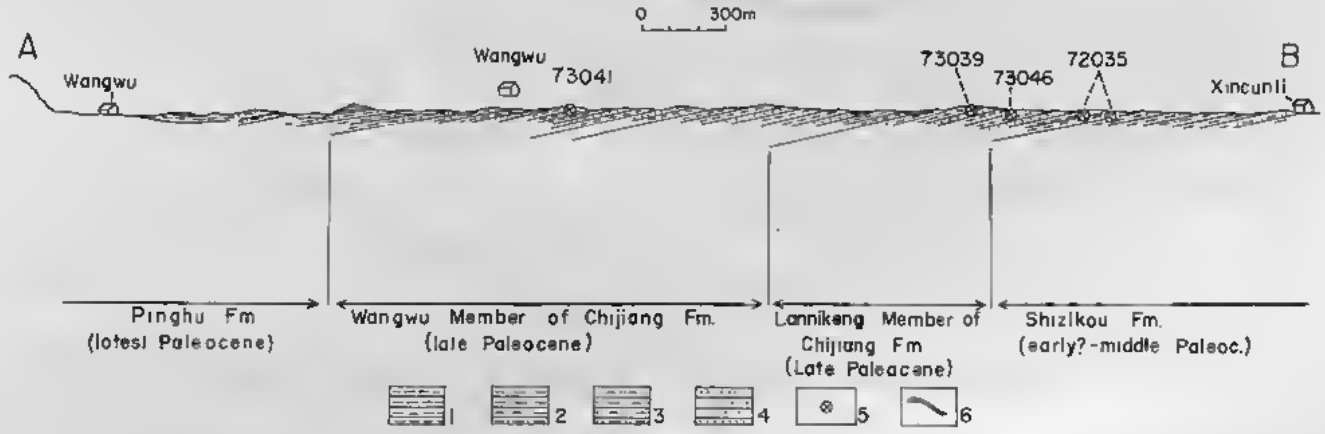


FIG. 10. — Cross section taken between Wangwu and Xincunli. **1** mudstone; **2.** argillaceous sandstone; **3.** sandy mudstone; **4.** sandstone. 5. fossil mammal locality. **6.** Recent covering. Modified from Tong *et al.*, 1976.

Source : MNHN, Paris

Fauna of the Shizikou Fm.

PANTODONTA

BEMALAMBDIDAE — *Bemalambda shizikouensis* Wang & Ding, 1979
— *Bemalambda* sp.; cited by Wang & Ding, 1979

PANTOLAMBDODONTIDAE Indet.; cited by the S. China "Redbeds" Group, 1977 (as "archaeolambdids")

Lat. 34° 25′ N, approx.
Long. 110° 15′ E, approx.

Fig. 2, n° 38

CHINA
SHAANXI PROVINCE
(Shensi)
Shimen Basin

Fangou Fm. **early? — middle Paleocene**
Locality: Yanghe

Fossil mammals were found in the Shimen [19] Basin in 1977 by Xue (Xue, 1978) and her colleagues from Northwestern University, Xian. IVPP members Qi and Huang visited the basin the following year. Out of the many specimens collected, the mesonychid remains were described by Qi and Huang in 1982. In 1978 an insectivore skull was discovered (Xue & Zhao, 1982) which McKenna *et al.*, described in 1984.

The fossil locality, Yanghe [20], is situated in the Fangou [21] Valley near Shimen Commune, Lonan County. The Shimen Basin, like the Tantou Basin farther east in Henan Province, is an intermontane basin in the Qinling Range. It is small (about 52 km^2 in area) and is located about 110 km east of Xian and 15 km north of Lonan. The basin is fault-bounded and contains three Cenozoic rock units lying on a Sinian (Precam-

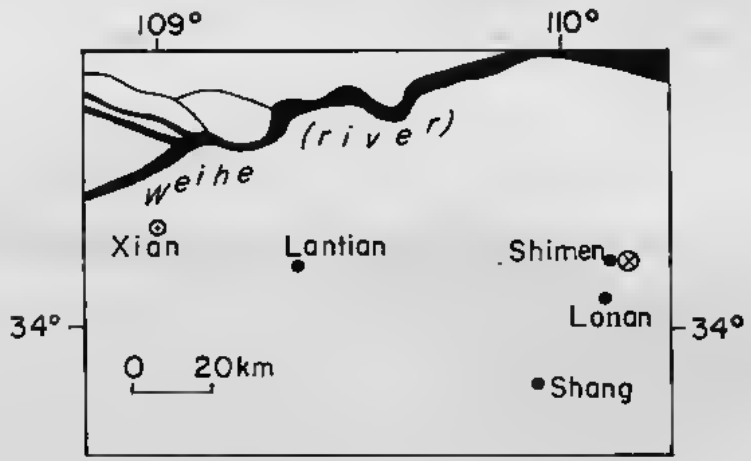
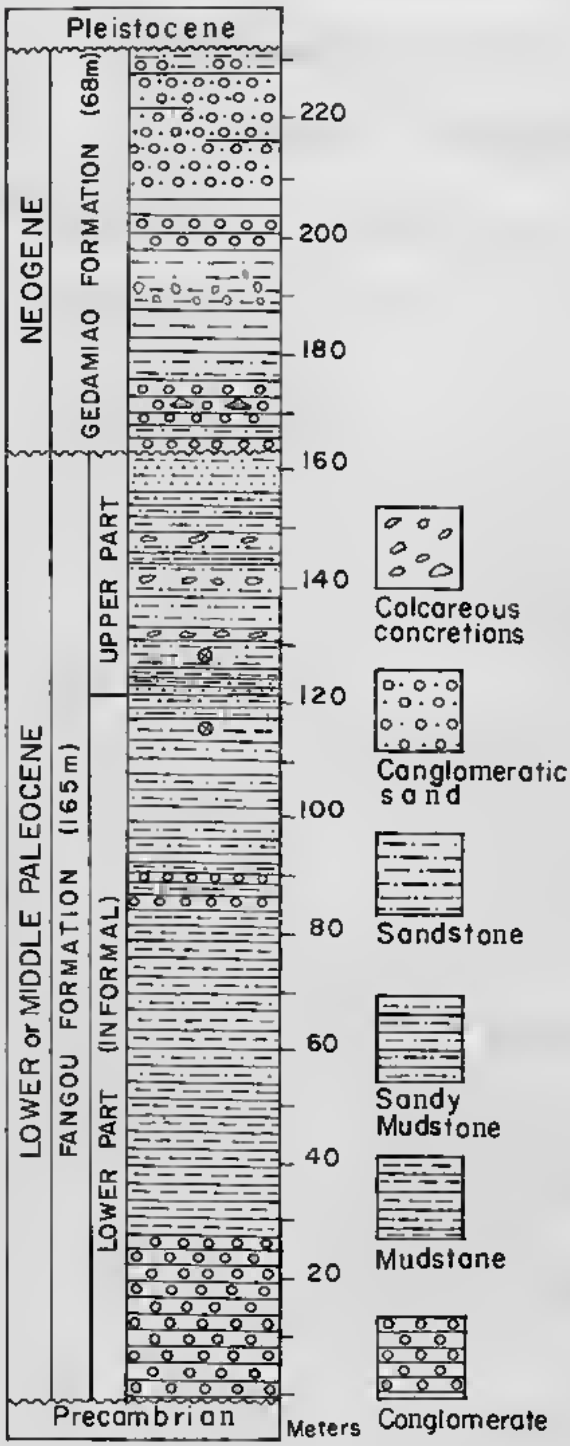


FIG. 11. Map showing the Paleogene fossil mammal locality in the Shimen Basin, Shaanxi. Modified from Qi & Huang, 1982.

19 Shimen (= Shimem) = stone gate.
20 Yanghe = Yang River.
21 Fangou = Fang (family name) Valley.

Source : MNHN, Paris



brian) basement. The Fangou Formation is widely distributed in the basin and consists of brown-red, dense, sandy mudstones. It has been informally divided into upper and lower parts: the mudstones of the upper part (41 m) are interlayered with several gray-green conglomeratic sandy mudstones and silty sandstones containing many calcareous concretions. The lower part (124 m) contains several thin conglomeratic layers in the middle and a thick one at the base. The formation is unconformably limited, underneath by the Precambrian Gaushanhe Formation and above by the Gedamiao [22] Formation of Miocene or Pliocene age.

Fossils have been recovered in both parts of the Fangou Formation; bamalambdid pantodont material was found 6 m above the base of the upper part of the formation while 6 m below the top of the lower part anagalid, bemalambdid, mesonychid and micropternodontid remains were collected. In lithostratigraphy as in geological structure the Shimen Basin is very similar to the Nanxiong Basin of Guangdong, and what is known of the fauna of the Fangou Formation seems to be like that of the Shanghu Formation of the latter basin.

FIG. 12. — Generalized stratigraphic section of the Tertiary deposits of the Shimen Basin, Shaanxi. Modified from McKenna *et al.*, 1984

Fauna of the Fangou Fm.

INSECTIVORA

MICROPTERNODONTIDAE — *Prosarcodon lonanensis* McKenna *et al.*, 1984

PANTODONTA

BEMALAMBDIDAE Indet.; cited by Xue, 1978, V.P. (4)

22 Gedamiao = knotty temple.

Source : MNHN, Paris

ANAGALIDA
ANAGALIDAE — *Linnania* sp.; cited by McKenna *et al.*, 1984
CONDYLARTHRA
MESONYCHIDAE — *Hukoutherium shimemensis* Qi & Huang, 1982, V.P. (I)

EARLY? to MIDDLE PALEOCENE

Composite list

(**Chi**: Chijiang Basin; **Nan**: Nanxiong Basin; **Qia**: Qianshan Basin; **Shi**: Shimen Basin)

INSECTIVORA
MICROPTERNODONTIDAE
Shi — *Prosarcodon lonanensis*

PANTODONTA
BEMALAMBDIDAE
Nan — *Bemalambda nanhsiungensis*
Nan — *Bemalambda pachyoesteus*
Nan — *Bemalambda crassa*
Chi — *Bemalambda shizikouensis*
Chi, Nan, Qia — *Bemalambda* sp.
Shi, Qia BEMALAMBDIDAE Indet.
Chi PANTOLAMBDODONTIDAE Indet.
HARPYODIDAE
Qia — *Harpyodus euros*
PASTORALODONTIDAE
Qia — *Altilambda pactus*
Qia — *Altilambda tenuis*

TILLODONTIA
TILLOTHERIIDAE
Nan — *Lofochaius brachyodus*

TILLODONTIA ?
FAMILY Incert. sed.
Nan — *Dysnoetodon minuta*

ANAGALIDA
ANAGALIDAE
Nan — *Linnania lofoensis*
Shi — *Linnania* sp.
Qia — *Huaiyangale chianshanensis*
Qia — *Huaiyangale* sp.
Qia — *Diacronus anhuiensis*
Qia — *Diacronus wanghuensis*
Qia — *Wanogale hodungensis*
Qia — *Chianshania qianghuaiensis*
Qia — *Anaptogale wanghoensis*
PSEUDICTOPIDAE
Qia — *Anictops tabiepedis*
Qia — *Anictops* aff. *tabiepedis*
Qia — *Cartictops canina*
Qia — *Paranictops majuscula*
Qia — *Paranictops*? sp.

Source : MNHN, Paris

ASTIGALIDAE

Qia — *Astigale wanensis*
Nan — *Astigale nanxiongensis*
Nan — *Zhujegale lirenensis*
Nan — *Zhujegale jintangensis*

MIXODONTIA

EURYMYLIDAE

Qia — *Heomys* sp.

MIMOTONIDAE

Qia — *Mimotona wana*
Qia — *Mimotona* sp.

CARNIVORA

VIVERRAVIDAE

Qia — *Pappictidops orientalis*
Nan — *Pappictidops acies*
Nan — *Pappictidops obtusus*

CONDYLARTHRA

PERIPTYCHIDAE

Nan — *Ectoconus*? sp.

HYOPSODONTIDAE

Nan — *Yuodon protoselenoides*
Nan — *Palasiodon siurenensis*
Qia — *Decoredon elongetus*

MESONYCHIDAE

Qia — *Yantanglestes conexus*
Nan — *Yantanglestes feiganensis*
Nan — *Dissacusium shanghoensis*
Nan — *Hukoutherium ambigum*
Shi — *Hukoutherium shimemensis*

ORDER Indet

ZALAMBDALESTIDAE

Qia — *Anchilestes impolitus*

DIDYMOCONIDAE

Qia — *Zeuctherium niteles*

ORDER & FAMILY Indet.

Qia — *Obtususdon hanhuaensis*

Source : MNHN, Paris

Lat. 34° 00′ N
Long. 111° 46′ E
(Tantou Town)

Fig. 2, n° 12

CHINA
HENAN PROVINCE
Tantou Basin

Gaoyugou Fm. **middle Paleocene**

The small Tantou [1] Basin, one of the many intermontane basins filled with Cretaceous and early Tertiary sediments in western Henan, was first investigated by personnel from the Geological Institute of Hubei. The younger deposits were divided into 4 formations (I-IV), called the Tantou Group, but the formations were not formally named. Later, dinosaurs were discovered in the lower beds of the basin. In 1977-1978, a team from the IVPP discovered fossil mammals in the Tertiary rocks and named these strata the Gaoyugou Formation (the lowest, or bed I, of middle Paleocene age), the Dazhang Formation (or bed II, late Paleocene) and the Tantou Formation (III, originally thought to be early Eocene). The fourth, or top formation, was not found to be fossiliferous and was not named.

The Gaoyugou Formation [2] consists mainly of purplish red mudstone. In its lower part intercalated gravel beds are sometimes present; the upper part of the red mudstone contains grayish green shales. The thickness of the formation (at the Gaoyugou section) is 302 m but elsewhere 366 m have been measured. It is overlain by the late Paleocene Dazhang Formation and underlain by the late Cretaceous Qiuba [3] Formation.

To date, only a skull and a pair of lower jaws of *Bemalambda* and some fragments of mesonychid have been collected, but more material is sure to be discovered. In South China the genus *Bemalambda* is restricted to beds older than the late Paleocene.

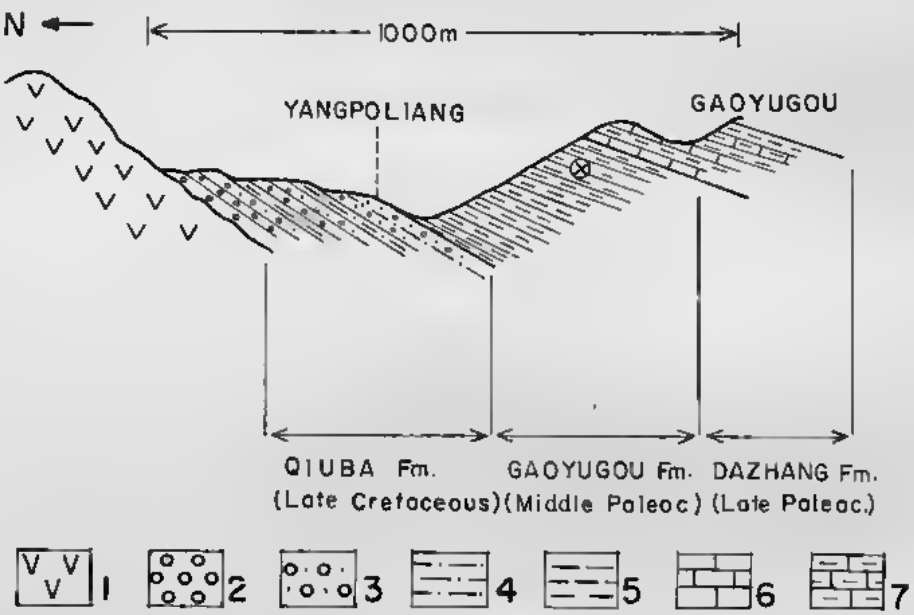


FIG. 13. Cross section taken between Yangpoliang and Gaoyugou, Tantou Basin, Henan. 1. Sinian Xiongcr Group; 2. conglomerate; 3. conglomeratic sandstone; 4. sandy mudstone; 5. mudstone; 6. limestone; 7. argillaceous limestone. Modified from Tong & Wang, 1980.

1 Tantou = source of pond.
2 Gaoyugou = Gao (family name) Valley.
3 Qiuba = a place name.

Source : MNHN, Paris

Fauna of the Gaoyugou Fm.

PANTODONTA
BEMALAMBDIDAE — *Bemalambda* sp.; cited by Tong & Wang, 1980, V.P. (1)
CONDYLARTHRA
MESONYCHIDAE indet.; cited by Tong & Wang, 1980, V.P. (1)

Lat. 26° 38′ - 26° 48′ N
Long. 113° 24′-113° 34′ E
(Chaling City: 26° 48′ N, 113° 33′ E)

Fig. 2, n° 20

CHINA
HUNAN PROVINCE
Chaling Basin

Zaoshi Fm. **middle Paleocene**

The Chaling Basin, situated in Chaling County, southeastern Hunan Province, yielded the first determinable fossils in 1964. In 1972, a prospecting crew from the IVPP firmly established the paleontological richness of this basin.

The middle Paleocene strata, named the Zaoshi [4] Formation, consist of purplish red sandy claystones of about 50 m in thickness; they crop out to the south of Chaling City. The late Cretaceous Daijiaping [5] Formation underlies it disconformably and occupies most of the basin (thickness 911-3226 m).

The presence of several bemalambdids in the Zaoshi Formation establishes its middle Paleocene age, in accordance with correlative principles based on analyses of other Chinese Paleocene faunas. The relatively advanced state of the tillodont from the Zaoshi Formation, compared to that from the Shanghu Formation (Nanxiong Basin), suggests that the Zaoshi Formation may represent only the upper part of the early(?)-middle Paleocene red bed sequence.

Fauna of the Zaoshi Fm.

PANTODONTA
BEMALAMBDIDAE
— *Hypsilolambda chalingensis* Wang, 1975, V.P. (3)
— *Hypsilolambda impensa* Wang, 1975, V.P. (3)
— *Hypsilolambda* spp.; cited by Wang, 1975, V.P. (3)
— *Bemalambda nanhsiungensis* Chow *et al.*, 1973, V.P. (1)
— Bemalambdidae indet.; cited by Wang, 1975, V.P. (3)
TILLODONTIA
TILLOTHERIIDAE — *Meiostylodon zaoshiensis* Wang, 1975, V.P. (3)
ANAGALIDA
ANAGALIDAE — *Stenanagale xiangensis* Wang, 1975, V.P. (3)

4 Zaoshi (= Tsaoshih = Zhaoshih) = date market.
5 Daijiaping (= Taichiaping = Techiapin) = Daijia (the Dai family) Plain.

Source : MNHN, Paris

CONDYLARTHRA

MESONYCHIDAE — *Yantanglestes rotundus* (Wang, 1975) Ideker & Yan, 1980, V.P. (2)
(= *Lestes rotundus* (Wang, 1975) Yan & Tang, 1976, V.P. (4))
(= *Dissacus? rotundus* Wang, 1975, V.P. (3))

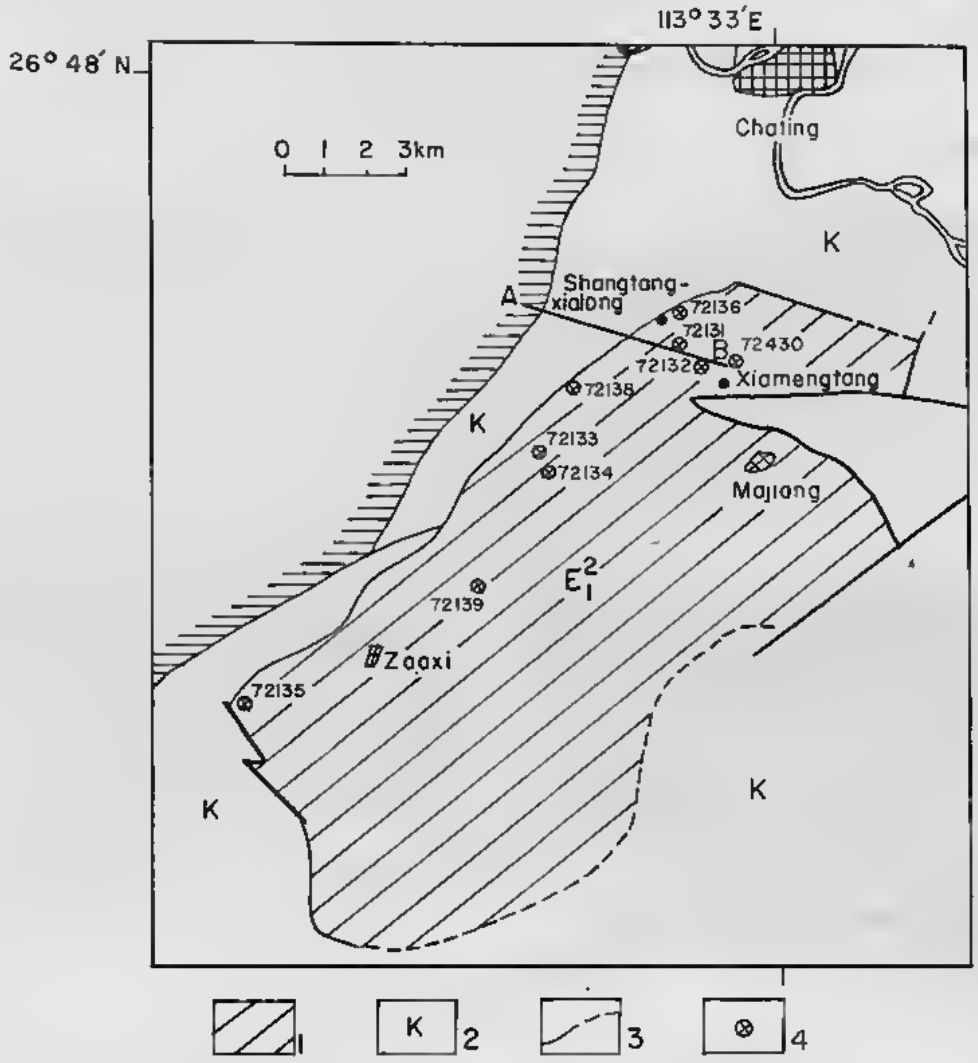


FIG. 14. — Map of the Chaling Basin, Hunan. **1**. Zaoshi Fm.; **2**. late Cretaceous Daijiaping Fm.; **3**. stratigraphic boundary, or fault; **4**. fossil mammal locality. Modified from GAO, 1975.

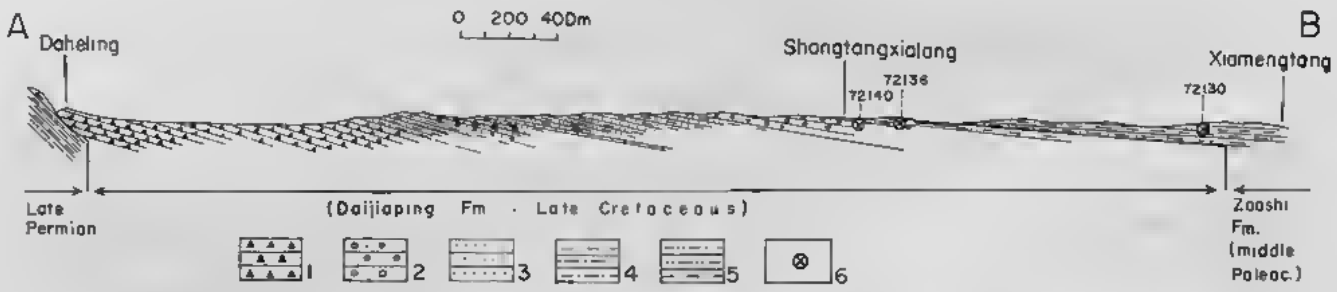


FIG. 15. — Cross section taken between Daheling and Xiamengtang, Chaling Basin. Hunan. **1** breccia; **2**. gravelly sandstone; **3**. sandstone; **4** sandy mudstone; **5**. argillaceous sandstone; **6**. fossil mammal locality. Modified from GAO, 1975.

Source : MNHN, Paris

MIDDLE PALEOCENE

Composite list

(**Cha**: Chaling Basin; **Tan**: Tantou Basin)

PANTODONTA

BEMALAMBDIDAE

Cha — *Bemalambda nanhsiungensis*
Tan — *Bemalambda* sp.
Cha — *Hypsilolambda chalingensis*
Cha — *Hypsilolambda impensa*
Cha — *Hypsilolambda* sp.
Cha — Bemalambdidae sp.

TILLODONTIA

TILLOTHERIIDAE

Cha — *Meiostylodon zaoshiensis*

ANAGALIDA

ANAGALIDAE

Cha — *Stenanagale xiangensis*

CONDYLARTHRA

MESONYCHIDAE

Cha — *Yantanglestes rotundus*
Tan — Mesonychidae indet.

Source : MNHN, Paris

Lat. 30° 35′ - 30° 45′ N
Long. 116° 28′ - 116° 38′ E
(Qianshan City: 30° 36′ N, 116° 36′ E)

Fig. 2, n° 15

CHINA
ANHUI PROVINCE
Qianshan Basin

Doumu Fm. **late Paleocene**

For more information on the Qianshan Basin and its sediments, refer to the discussion of the early?-middle Paleocene Wanghudun Formation (p. 28). The uppermost strata in this basin are of the Doumu Formation; it is made up principally of purplish red conglomerate and conglomeratic sandstones and mudstones, with a thickness of about 600 m. An upper and a lower member may be distinguished on a lithological basis.

The Doumu Formation can be correlated with the Shuangtasi and Chijiang Formations by its anagalid and notoungulate, as well, of course, as by the presence of *Archaeolambda*. Both the upper and lower parts of the formation are regarded as late Paleocene in age. The identification of *Hyracolestes* in this fauna is not certain.

Fauna of the Doumu Fm. (upper part)

PANTODONTA
PANTOLAMBDODONTIDAE — *Archaeolambda tabiensis* Huang, 1977, V.P. (4)
ANAGALIDA
ANAGALIDAE — *Hsiuannania* sp.; cited by Xu, Q., 1976a, V.P. (3)
MIXODONTIA
EURYMYLIDAE — *Heomys orientalis* Li, 1977, V.P. (2)
MIMOTONIDAE — *Mimotona wana* Li, 1977, V.P. (2)
EURYMYLOIDAE indet.; cited by Li, 1977, V.P. (2)
NOTOUNGULATA
ARCTOSTYLOPIDAE — *Sinostylops promissus* Tang & Yan, 1976, V.P. (2)
ORDER Indet.
FAMILY Indet. — *Hyracolestes ermineus* Matthew & Granger, 1925a; cited by Qiu *et al.*, 1977, V.P. (2)

Fauna of the Doumu Fm. (lower part)

ANAGALIDA
ANAGALIDAE — *Hsiuannania tabiensis* Xu, Q., 1976a, V.P. (3)
PSEUDICTOPIDAE — *Allictops inserrata* Qiu, Z.-x., 1977
MIXODONTIA
MIMOTONIDAE — *Mimotona robusta* Li, 1977, V.P. (2)
ORDER Indet.
FAMILY Indet. — *Obtususdon hanhuaensis* Xu, 1977, V.P. (2)

Source : MNHN, Paris

Lat. 30° 58′ N
Long. 118° 45′ E
(Xuancheng City)

Fig. 2, n° 17

CHINA
ANHUI PROVINCE
Xuancheng Basin

Shuangtasi Fm. **Late Paleocene**

In the Xuangcheng [1]-Guangde [2] Basin of Anhui Province, south of the Changjiang [3] River, is a thick series of red beds. All the published material was collected during the year of its discovery, 1971, although two later expeditions also recovered fossil mammals. These red beds were called the Shuangtasi [4] Series, but they are now divided into an upper formation, the Shuangtasi Formation, and a lower, Cretaceous one, the Xuannan [5] Formation. The sediments are mostly coarse grained detritals. Cretaceous and Tertiary rocks are restricted to scattered, isolated patches; outcrops are few as most of the area is covered by Quaternary deposits. Structurally, the Xuancheng region is not a basin like that of Nanxiong, but is more like a depression, although its nature is not yet really clear.

Correlation of the Shuangtasi Formation is

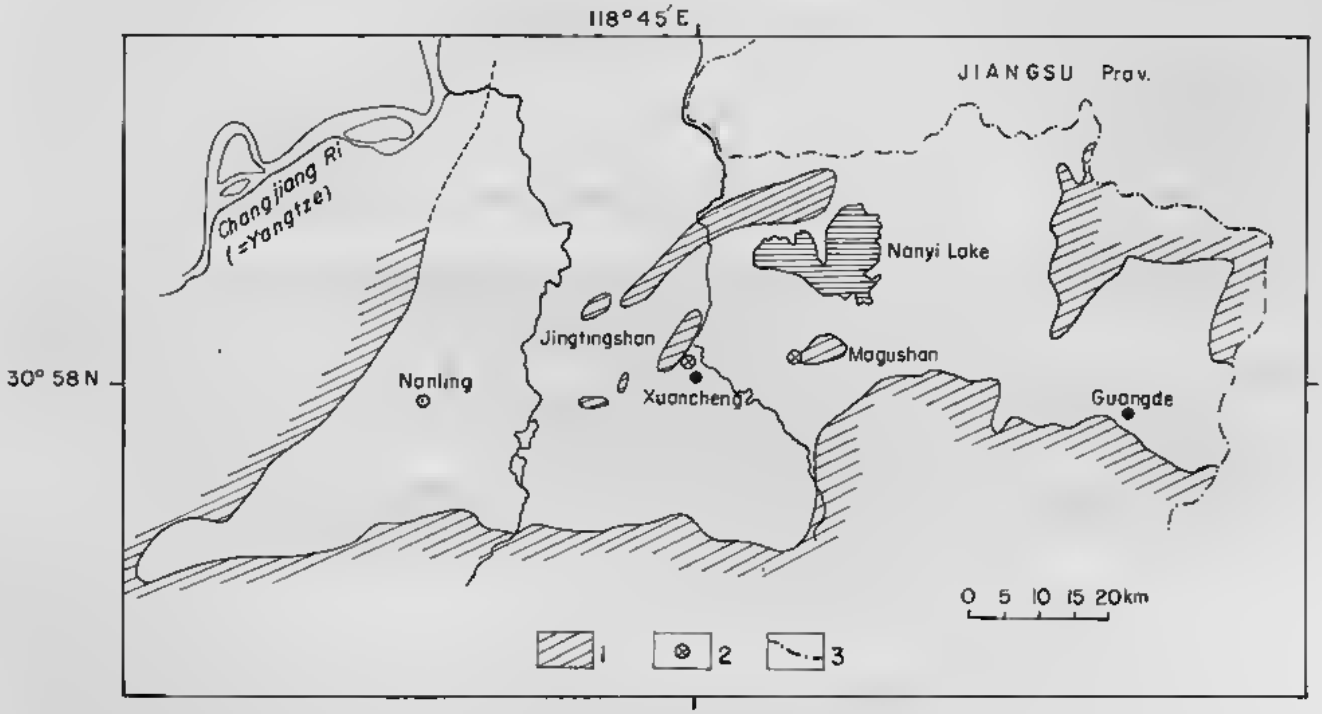


FIG. 16. — Vertebrate fossil localities of the Xuancheng Depression, Anhui 1. Paleozoic rocks; 2. fossil mammal locality; 3. boundary between provinces. Modified from Qiu *et al.*, 1977.

1 Xuangcheng (= Hsuancheng = Hsuankuang) = Proclamation City.
2 Guangde (= Kuangte) = expansive virtue.
3 Changjiang (= Yangze = Yangtze) = long river.
4 Shuangtasi (= Xuangtasi = Shuantaszu = Sontas) = two pagoda monestary.
5 Xuannan = south of Proclamation City.

Source : MNHN, Paris

best made with the faunas of Gashato age; the species of *Archaeolambda* is also advanced with respect to other forms considered to be late Paleocene, as is the arctostylopid, although the latter is structurally more primitive than the Gashato *Arctostylops*.

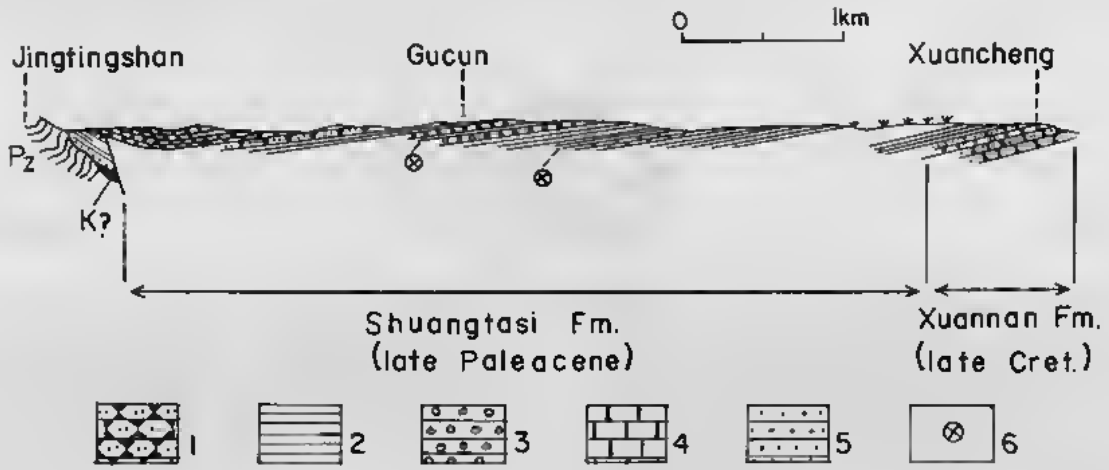


FIG. 17. — Cross section taken between Jingtingshan (mountain) and Xuancheng, Anhui. **1.** thick-layered sandstone; **2.** mudstone; **3.** conglomerate; **4.** argillaceous limestone; **5.** sandstone; **6.** fossil mammal locality. Modified from Qiu *et al.*, 1977.

Fauna of the Shuangtasi Fm.

PANTODONTA
PANTOLAMBDODONTIDAE — *Archaeolambda yangtzeensis* Huang, 1978, V.P. (4)

ANAGALIDA
ANAGALIDAE — *Hsiuannania maguensis* Xu, Q., 1976a, V.P. (3)

CONDYLARTHRA
MESONYCHIDAE — *Dissacus magushanensis* Yan & Tang, 1976, V.P. (4)
(= *Dissacus? magushanensis* Yan & Tang, 1976; cited by the South China " Redbeds " Group, 1977

NOTOUNGULATA
ARCTOSTYLOPIDAE — *Sinostylops progressus* Tang & Yan, 1976, V.P. (2)

ORDER Indet.
FAMILY Indet. — *Wanotherium xuanchengensis* Tang & Yan, 1976, V.P. (2)

Source : MNHN, Paris

Lat. 25° 00′ - 25° 10′ N
Long. 114° 15′ - 114° 30′ E

Fig. 2, n° 22

CHINA
GUANGDONG PROVINCE
(KWANGTUNG)
Nanxiong Basin

Nongshan Fm. **late Paleocene**

More complete information on the Nanxiong Basin can be found in the discussion of the early?-middle Paleocene Shanghu Formation (p. 31).

The Nongshan Formation may be divided lithologically into three parts. The lower part, the Zhuguikeng Member[6], about 160 m thick, consists of grayish green sandy marls and purplish red marls; the middle part, the Datang[7] Member, about 150 m thick, consists of purplish red mudstone and argillaceous sandstones; and the upper part, not named, also about 150 m thick, is made up of purplish and grayish argillaceous sandstones and sandy mudstones. Vertebrate fossils occur only in the lower and middle parts of the formation.

The age of the sediments in the Nanxiong Basin is difficult to determine. The Nongshan Formation is taken to be late Paleocene, but as for all the formations in China considered to be of Paleocene age, this determination is the result of reasoning based on its stratigraphic situation in the sequence and on the stage of evolution of the included mammals. The absence of bemalambdids, typical of the underlying (and supposedly middle Paleocene) beds, the appearance of arctostylopids and phenacolophids which indicate a distinctly higher level (but the phenacolophids are more primitive than those of the Gashato fauna), and the primitivity of the pastoralodont compared to that of Nomogen (a Gashato equivalent), all indicate for this formation an age not as old as middle Paleocene and not younger than late Paleocene, but perhaps younger than Gashato and Nomogen.

Fauna of the Nongshan Fm. (middle part, Datang Member)

PRIMATES?
- ADAPIDAE? — *Petrolemur brevirostre* Tong, 1979c, V.P. (1)[8]

PANTODONTA
- PANTOLAMBDODONTIDAE — *Archaeolambda* sp., *in* Lucas, 1982 (= *Nanlingilambda* sp.; cited by Tong, 1982, V.P. (1))
- PASTORALODONTIDAE — *Altilambda pactus* Chow & Wang, 1978, V.P. (2)
- — *Altilambda minor* Tong, 1982, V.P. (1)
- — *Altilambda* sp.; cited by Tong, 1982, V.P. (1)

ANAGALIDA
- ANAGALIDAE — cf. *Huaiyangale leura* Ding & Tong, 1979, V.P. (2)
- PSEUDICTOPIDAE — *Haltictops mirabilis* Ding & Tong, 1979, V.P. (2)
- — *Haltictops meilingensis* Ding & Tong, 1979, V.P. (2)
- FAMILY Indet. — *Interogale datangensis* Huang & Zheng, 1983, V.P. (1)

6 Zhuguikeng = bamboo and laurel puddle.
7 Datang = big pond.
8 Order and family doubted by the authors; Szalay (1982) suggests that it is a dichobunid artiodactyl.

Source : MNHN, Paris

CONDYLARTHRA
MESONYCHIDAE — *Yantanglestes datangensis* (Wang, 1976) Ideker & Yan, 1980, V.P. (2) (= *Lestes datangensis* Wang, B., 1976, V.P. (4)

CONDYLARTHRA?
PHENACOLOPHIDAE — *Minchenella grandis* (Zhang, 1978) Zhang, 1980, V.P. (3) (= *Conolophus grandis* Zhang, 1978, V.P. (4))
— *Yuelophus validis* Zhang, 1978, V.P. (4)

EDENTATA?[9]
ERNANODONTIDAE — *Ernanodon antelios* Ding, 1979, V.P. (1)

NOTOUNGULATA
ARCTOSTYLOPIDAE — gen. & sp. nov.; cited by the South China " Redbeds " Group, 1977.

Fauna of the Nongshan Fm. (lower part, Zhuguikeng Member)

PANTODONTA
PANTOLAMBDODONTIDAE — *Archaeolambda zhuguikengensis* (Tong, 1982) (= *Dilambda zhuguikengensis* Tong, 1982, V.P. (1); *Dilambda* was synonymized with *Archaeolambda* by Lucas, 1982) (= gen. & sp. nov.; cited by the South China " Redbeds " Group, 1977)

CONDYLARTHRA
MESONYCHIDAE — *Pachyaena*? sp.; cited by Wang, B., 1976, V.P. (4)

CONDYLARTHRA?
PHENACOLOPHIDAE — gen. & sp. nov.; cited by the South China " Redbeds " Group, 1977)

Lat. 34° 00′ N
Long. 111° 46′ E
(Tantou Town)

Fig. 2, n° 12

CHINA
HENAN PROVINCE
(Honan)
Tantou Basin

Dazhang Fm. **late Paleocene**

For the history of investigation in this basin, refer to the discussion concerning the middle Paleocene Gaoyugou Formation (p. 40).

The Dazhang[10] Formation also yielded fossil mammal material during the field season of 1977-1978 to IVPP workers. Its lithology varies greatly; at the Gaoyugou section, a grayish green, coarse sandstone appears at the bottom of the formation and gravels occur. Higher up, dark red, grayish green clay contains intercalations of marl. Near the top it is mainly gray white marls, but this section is not complete (thickness 104 m). Elsewhere, the formation consists, in its lower part, of brown gravel and sandstone, purplish red or gray and greenish clay; toward the top, oil shales appear; thickness, 375 m.

9 Order doubted by M. C. McKenna (pers. com., 1985).
10 Dazhang = big Zhang (family name).

Source : MNHN, Paris

The two taxa discovered in this formation (and still undescribed) would probably indicate a late Paleocene age. The stratigraphical sequence in the Tantou Basin is very like that in other basins of a similar sedimentary nature, such as the Nanxiong Basin and the Chijiang Basin. We will tentatively consider the Dazhang Formation to be late Paleocene in age.

Fauna of the Dazhang Fm.

PANTODONTA

PASTORALODONTIDAE Indet.; cited by Tong & Wang, 1980, V.P. (1)

ANAGALIDA

PSEUDICTOPIDAE Indet.; cited by Tong & Wang, 1980, V.P. (1)

Lat. 34° 00′ N
Long. 111° 46′ E
(Tantou Town)

Fig. 2, n° 12

CHINA
HENAN PROVINCE
(Honan)
Tantou Basin

Tantou Fm. late Paleocene

This basin has been discussed earlier when the fauna of the Gaoyugou Formation was cited (p. 40). Fossil mammals were discovered in the Tantou Formation the same field season (1977-1978) as were those in the older Tantou Basin Tertiary sediments.

The Tantou Formation consists mainly of grayish green, gray white, dark gray mudstone, shales, marls and oil shales; some sandstone also occurs. Formational thickness varies from 136 m at the Gaoyugou section to a maximum of 458 m elsewhere. The Tantou Formation is overlain by the formation termed IV, which is not named and is unfossiliferous. It is underlain by the Dazhang Formation, which is also considered as late Paleocene.

According to the still undescribed material from these beds, they could be contemporary with the strata that furnished the Gashato or the Bayn Ulan faunas. Another argument for this age determination is the placement of the formation within the stratigraphic sequence, similar to that found in basins of similar type in south China.

Fauna of the Tantou Fm.

PANTODONTA

PANTOLAMBDODONTIDAE Indet.; cited by Tong & Wang, 1980, V.P. (1)

DINOCERATA Indet.; cited by Schoch & Lucas, 1985
(= Prodinoceratinae indet.; cited by Tong & Wang, 1980, V.P. (1))

Source : MNHN, Paris

Lat. 25° 23' - 25° 40' N
Long. 114° 20'-114° 45' E

Fig. 2, n° 21

CHINA
JIANGXI PROVINCE
(Kiangsi)
Chijiang Basin

Chijiang Fm. **late Paleocene**

For the introduction to the Chijiang Basin, consult the section on the middle Paleocene Shizikou Formation (p. 34). The late Paleocene Chijiang [11] Formation, up to 500 m in thickness, has been divided into three members: an unnamed, unfossiliferous (lower) one, the (middle) Lannikeng [12] Member, and the (upper) Wangwu [13] Member. While all three of them are characterized by purplish red marls, the lower and the upper members are more sandy than the Lannikeng Member, which is also more frequently grayish green in color. Mammalian fossils occur only in the Lannikeng and Wangwu levels of the formation. The Pinghu Formation overlies these beds.

With respect to other Chinese faunas of comparable aspect or composition, a late Paleocene age for the Chijiang Formation is indicated by the pantolambdodontids and supported by the stage of evolution of the anagalid and arctostylopids. But since no genera are shared with the Gashato fauna, it is necessary to envisage that either a different paleoenvironment is represented at Chijiang or that the fauna is somewhat older. For what it is worth, the *Asiostylops* here shows a lesser degree of evolutionary development than the Gashato *Arctostylops* (= " *Palaeostylops* ").

Fauna of the Chijiang Formation (Wangwu Member)

PANTODONTA
PANTOLAMBDODONTIDAE — *Archaeolambda* sp.; cited by Tong, 1979a
CONDYLARTHRA
MESONYCHIDAE — *Jiangxia chaotoensis* Zhang *et al.*, 1979
NOTOUNGULATA
ARCTOSTYLOPIDAE — *Allostylops periconotus* Zhang, 1979b

Fauna of the Chijiang Formation (Lannikeng Member)

INSECTIVORA — genus and species indet.; cited by Ding & Zhang, 1979
PANTODONTA
PANTOLAMBDODONTIDAE — *Archaeolambda dayuensis* Tong, 1979a
— *Archaeolambda* cf. *planicanina* Flerov, 1952b; cited by Tong, 1979
— *Archaeolambda speciosa* (Tong, 1978) Lucas, 1982
(= *Dilambda speciosa* Tong, 1978)
(= *Nanlingilambda chijiangensis* Tong, 1979a)
(= *Nanlinglamba*, cited by Tong *et al.*, 1976, V.P. (1), *nomen nudum*)
HARPYODIDAE — *Harpyodus decorus* Wang, 1979

11 Chijiang (= Chihkiang) = pond river.
12 Lannikeng = mud puddle.
13 Wangwu = Wang's house.

Source : MNHN, Paris

ANAGALIDA
- ANAGALIDAE — *Hsiuannania minor* Ding & Zhang, 1979
- PSEUDICTOPIDAE — *Pseudictops? tenuis* Ding & Zhang, 1979

CONDYLARTHRA
- PERIPTYCHIDAE — *Pseudanisonchus antelios* Zhang *et al.*, 1979
- HYOPSODONTIDAE Indet.; cited by Zhang *et al.*, 1979
- MESONYCHIDAE — *Hapalodectes*? sp.; cited by Zhang *et al.*, 1979

CONDYLARTHRA?
- PHENACOLOPHIDAE — *Ganolophus lanikenensis* Zhang, 1979

NOTOUNGULATA
- ARCTOSTYLOPIDAE — *Asiostylops spanios* Zhang, 1979b

ORDER Indet.
- DIDYMOCONIDAE — *Archaeoryctes notialis* Zheng, 1979a

Lat. 25° 23′ - 25° 40′ N
Long. 114° 20′-114° 45′ E

Fig. 2, n° 21

CHINA
JIANGXI PROVINCE
(Kiangsi)
Chijiang Basin

Pinghu Fm. **late Paleocene**

Prospecting parties of the IVPP in 1972 and 1973 discovered mammalian fossils in the Pinghu [14] Formation, which crops out in the northern part of the Chijiang Basin (for more details on this basin consult the section on the early?-middle Paleocene Shizikou Formation, p. 34). The lower part of the formation is composed of multicolored mudstones (light and dark brownish red and grayish green). Higher in the section gravels appear in the clay and to the west the whole formation becomes dominantly brick red with coarser sediments, such as sandy clay and sandstone. Its thickness varies from 200-300 m.

The Pinghu Formation has produced two specimens of Dinocerata which are very similar to the *Prodinoceras* from Gashato. However, the Gashato form is known to be nearly identical to Tiffanian and early Clarkforkian species from North America, along with Arctostylopidae. Since the Gashato assemblage may be considered as terminal Paleocene, it is likely that the Pinghu Formation is the same age. In the past, the latter was regarded as early Eocene.

Fauna of the Pinghu Fm.

DINOCERATA
- UINTATHERIIDAE — *Prodinoceras lacustris* (Tong, 1976b) Schoch & Lucas, 1985
  (= *Phenaceras lacustris* Tong, 1976b)
  (= *Ganatherium australis* Tong, 1976b)

14 Pinghu = Ping (place name) Lake.

Source : MNHN, Paris

Lat. 42° 43′ N
Long. 111° 30′ E

Fig. 2, n° 3

CHINA
NEI MONGOL AUTONOMOUS REGION
(Inner Mongolia)

Nomogen Fm. **late Paleocene**

Locality: Nomogen Commune

The fauna of the Nomogen Formation was discovered in 1975 by a crew from the IVPP working in collaboration with mapping geologists; exploitation of the sites has continued every year until 1980. There are two localities, Haliut [15], situated 6 km southeast of the Nomogen Commune, and Gonghudong [16], 4 km south of the same commune. The fossils were found in pits that had been dug by miners in search of celestite.

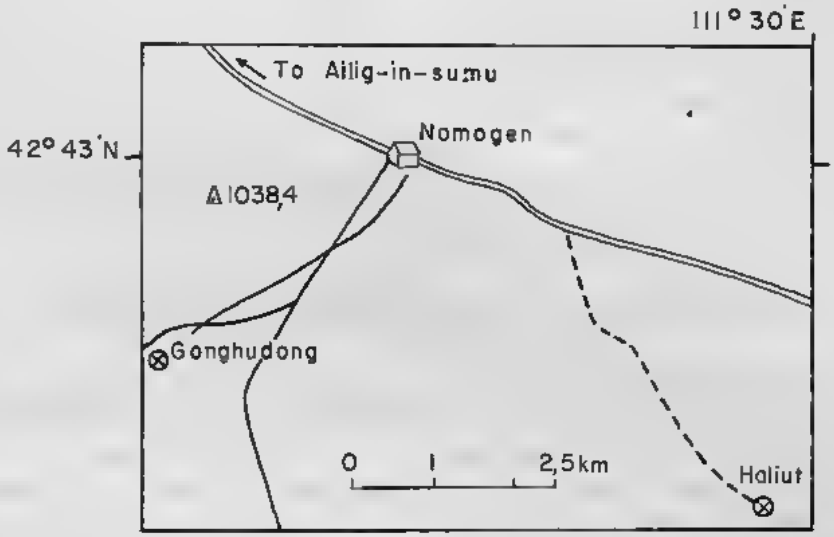


FIG. 18. – Map showing the Nomogen fossil localities, Nei Mongol. Modified from a map furnished by Qi Tao.

The Nomogen [17] Formation is mainly composed of red sandy clays of lacustrine origin. A thickness of 14 m is visible, but the bottom of the formation has not been observed. At the type locality of the Nomogen Formation no deposits overlie it, but a small hill not far away reveals the Irdin Manha Formation to be superjacent, though separated by a disconformity.

The age of the Nomogen Formation can be considered as equivalent to the Gashato Formation, as many of the genera and species are the same. However, the Nomogen Formation is lacustrine in origin, in contrast to that of Gashato. About 90 % of the fossils found belong to two forms, *Arctostylops iturus*, which is particularly abundant, and a recently described genus and species of multituberculate, *Lambdopsalis bulla*. Material of the latter was frequently found in celestite concretions, as were some other forms (pantodonts, for example).

15 Haliut = corral.
16 Gonghudong = deep well.
17 Nomogen (Nomkhong Shireh = Nomogen Ora = Naomugen) = holy.

Source : MNHN, Paris

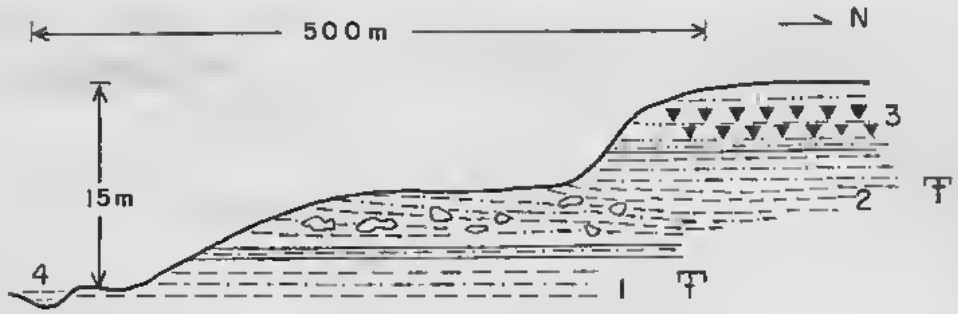


FIG. 19. — Cross section taken at Haliut, Si-Zi-Wang Qi (County), Nei Mongol, showing the Nomogen Formation. 1. dark red sandy clay with a thin-layered multicolored sandstone at the top; bottom not visible. Thickness more than 8 m; 2. dark red and grayish green argillaceous sandstone, containing celestite concretions. Thickness, 4 m; 3 light green sandstone, containing veins of gypsum. Thickness, 4 m; 4. dry stream bed. Modified from Zhou *et al.*, 1976.

Fauna of the Nomogen Fm.

MULTITUBERCULATA

TAENIOLABIDIDAE
- *Prionessus lucifer* Matthew & Granger, 1925a; cited by Chow & Qi, 1978, V.P. (2)
- *Sphenopsalis nobilis* Matthew, Granger & Simpson, 1928; cited by Chow & Qi, 1978, V.P. (2) [18]
- *Sphenopsalis*? sp.; cited by Chow & Qi, 1978, V.P. (2)

LAMBDOPSALIDAE
- *Lambdopsalis bulla* Chow & Qi, 1978, V.P. (2) [19]

INSECTIVORA

MICROPTERNODONTIDAE
- *Sarcodon pygmaeus* Matthew & Granger, 1925a; cited by Chow & Qi, 1978, V.P. (2)

PANTODONTA

PASTORALODONTIDAE
- *Pastoralodon lacustris* Chow & Qi, 1978, V.P. (2)
- *Pastoralodon convexus* (Chow & Qi, 1978) Lucas 1982 (= *Convallisodon convexus* Chow & Qi, 1978, V.P. (2))
- *Pastoralodon haliutensis* (Chow & Qi, 1978) Lucas, 1982 (= *Convallisodon haliutensis* Chow & Qi, 1978, V.P. (2))

ANAGALIDA

PSEUDICTOPIDAE
- *Pseudictops lophiodon* Matthew, Granger & Simpson, 1929; cited by Chow & Qi, 1978, V.P. (2)

MIXODONTIA

MIMOTONIDAE [20]
- *Mimotona borealis* Chow & Qi, 1978, V.P. (2)

CONDYLARTHRA

MESONYCHIDAE
- *Dissacus*? n. sp.; cited by Chow & Qi, 1978, V.P. (2)
- *Plagiocristodon serratus* Chow & Qi, 1978, V.P. (2)

NOTOUNGULATA

ARCTOSTYLOPIDAE
- *Arctostylops iturus* (Matthew & Granger, 1925a) Dashzeveg, 1979c (= *Palaeostylops iturus* Matthew & Granger, 1925a; cited by Chow & Qi, 1978, ibid.)

18 *Sphenopsalis* was removed from the Cimolomyidae and referred to the Taeniolabididae by Kielan-Jaworowska & Sloan, 1979.

19 This genus was considered as possibly synonymous with *Sphenopsalis* by Kielan-Kaworowska & Sloan, 1979. We maintain its distinction.

20 *Mimotona wana* was cited by error in this fauna by Chow & Qi, 1978, V.P. (2).

Source : MNHN, Paris

— *Arctostylops macrodon* (Matthew, Granger & Simpson, 1929) Dashzeveg, 1979c
(= *Palaeostylops macrodon* Matthew, Granger & Simpson, 1929; cited by Chow & Qi, 1978, V.P. (2)

RODENTIA?

— Gen. & sp. indet.; cited by Chow & Qi, 1978, V.P. (2)

Lat. 42° 30′ - 43° 30′ N
Long. 88° 00′ - 92° 00′ E
(Shanshan City: 42° 52′ N; 90° 10′ E

Fig. 2, n° 1

CHINA
XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)
Turpan Basin [21]

Taizicun Fm. — **late Paleocene**

Locality: Taizicun

Oil geologists in 1959 discovered mammalian fossils at a place they mapped as close to Taizicun [22]; later, this name was not known when the local people were interrogated. These fossils were sent to the IVPP for identification and were found to represent the first mammals of Gashatan age known in China. In 1964 and 1966 a team from the IVPP continued investigations of the area, extending it westward to the Huoyanshan [23] Mountains. The material collected on these last two expeditions was described by Tong (1978).

The Taizicun Formation crops out in the central part of the Turpan Basin, from the region of the village of Taizicun to the eastern part of the Huoyanshan. The sediment of this formation is mostly white and yellow coarse grained sandstone with some crossbedding; it is probably fluvial in origin and not lacustrine. At Taizicun village white sandstone predominates but, westward, in the Huoyanshan, the sandstone contains clay and brown and orange sandy clays in which 9 levels have been recognized. Its thickness varies from 65 m in the Huoyanshan Mountains to 35 m at Taizicun; further eastward the formation pinches out entirely.

The Taizicun Formation, like the Dabu Formation further east, is underlain by the late Cretaceous Subashi Formation. It is overlain mostly by the Liankan [24] Formation, possibly of late Eocene age.

Correlation of the Taizicun Formation is best made with the beds carrying the Gashato fauna and it may therefore also be considered of late Paleocene age. Its fauna is definitely older than that of the Dabu Formation in the eastern part of the Turpan Basin. The Taizicun *Prodinoceras* is close to the Gashato form, as is the species of *Pseudictops*. *Tienshanilophus* is very probably synonymous with *Phenacolophus* and is also a good indication of a similar age. It should be mentioned that *Huoyanotherium* shows only minor differences from *Prodinoceras* and that

21 Turpan = Turfan.
22 Taizicun = high village.
23 Huoyanshan = Flame Mountain; these mountains, which constitute the western one-third of the uplifted longitudinal range in the Turpan Basin, have earned their name by being not only red in color but being well known in China as one of the hottest places in the country.
24 Lian (place name); kan = a local system of water procurement whereby wells are dug to connect with an underground canal carrying melted snow water from the mountains out into the desert.

Source : MNHN, Paris

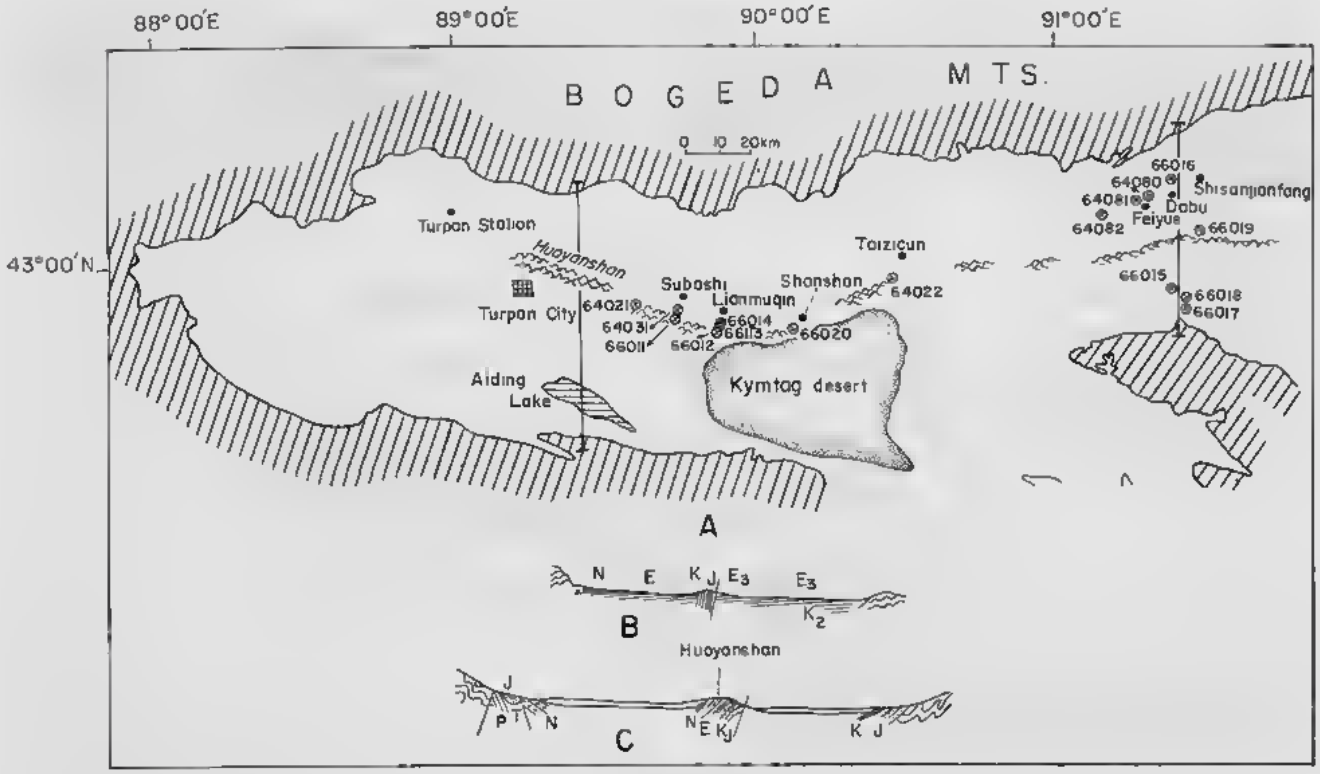


FIG. 20A. — Fossil mammal localities of the Turpan Basin, Xinjiang. P, Permian; J, Jurassic; T, Triassic; N, Neogene; K, Cretaceous; E, Paleogene. B. — Cross section through the eastern part of the Turpan Basin. C. — Cross section through the western part of the Turpan Basin. All modified from Zhai *et al.*, 1978. The sections are not to the scale of the map.

" *Dilambda* " *speciosa* is a species that has been referred to *Archaeolambda*. There is a possibility that the central part of the Taizicun Formation represents only the older part of the section that occurs in the west. For example, the *Prodinoceras* found at locality 64022, in the central part of the " middle " mountains, is more primitive than that from locality 64021 in the Huoyanshan, but primitive ones are also found, low in the section at the latter.

Fauna of the Taizicun Fm.

MULTITUBERCULATA? Indet.; cited by Tong, 1978

PANTODONTA

PANTOLAMBDODONTIDAE
— *Archaeolambda* cf. *planicanina* Flerov, 1952b; cited by Tong, 1978
— *Archaeolambda speciosa* (Tong, 1978) Lucas, 1982
(= *Dilambda speciosa* Tong, 1978)

DINOCERATA

UINTATHERIIDAE
— *Prodinoceras turfanensis* Chow, 1960, V.P. (2)
(= *Jiaoluotherium turfanense* (Chow, 1960) Tong, 1978, and Schoch & Lucas, 1985 [25]
(= *Prodinoceras martyr* Matthew, Granger & Simpson, 1929, *in* Dashzeveg, 1982b)

25 In their revision of the Dinocerata, Schoch & Lucas (1985) made no comment on the validity of the species.

Source : MNHN, Paris

— *Prodinoceras diconicus* Tong, 1978
— *Prodinoceras primigenum* (Tong, 1978) Schoch & Lucas, 1985 (= *Houyanotherium primigenum* Tong, 1978) [25]
— *Prodinoceras simplum* (Tong, 1978) Schoch & Lucas, 1985 (= *Houyanotherium simplum* Tong, 1978) [25]

ANAGALIDA
PSEUDICTOPIDAE — *Pseudictops chaii* Tong, 1978

MIXODONTIA
EURYMYLIDAE — n. gen., n. sp., cited by Tong, 1978

CONDYLARTHRA
MESONYCHIDAE Indet.; cited by Tong, 1978

CONDYLARTHRA?
PHENACOLOPHIDAE
— *Tienshanilophus subashiensis* Tong, 1978
— *Tienshanilophus lianmuqinensis*, Tong, 1978
— *Tienshanilophus shengjinkouensis* Tong. 1978

Lat. 44° 10′ N, approx.
Long. 103° 45′ E, approx.

Fig. 1, n° 26

MONGOLIA
OMONO GOBI PROVINCE
Ulan-Nur Basin

Khashat Svita **late Paleocene**

Locality: Gashato

The first paleontological expeditions into the Gobi (situated mostly in Outer Mongolia: Mongolian People's Republic, but extending into Inner Mongolia: Nei Mongol of the People's Republic of China) were those organized by the American Museum of Natural History from 1922 to 1930. After World War II, three Soviet expeditions were sent to Mongolia in 1946, 1948 and 1949. In 1959-1960 the Soviet Union and China organized a joint paleontological expedition to Inner Mongolia. A third series of paleontological explorations (as opposed to geological expeditions which frequently took place simultaneously) was initiated by the Polish Academy of Sciences in collaboration with the Academy of Sciences of the Mongolian People's Republic. Eight successive Polish-Mongol expeditions worked in southern Mongolia from 1963 to 1971. Soviet-Mongolian paleontological expeditions began in 1970 and have continued to the present. Working independently, Mongolian scientists have also successfully engaged in field work and collecting, resulting in the discovery of new localities and new taxa.

The Gashato [26] fauna is of interest in that for many years it represented the earliest Tertiary vertebrate fauna known in Asia. Recently, following the discovery of early Tertiary mammals in southern China, the Gashato assemblage has been used as a standard with which to compare the new faunas, hence its continuing importance.

The locality of Gashato occurs in the Ulan-Nur Basin at the edge of the north slope of the Gurvan-Saykhan [27] Range about 85 km NW of

26 Gashato (= Khashat = Kashiat = Khashaat) = a corral.
27 Gurvan-Saykhan = three beautiful (mountains).

Source : MNHN, Paris

Dalan-Dzadgada [28], 25 km E of the village of Bulgan [29], and 6 km SE of Bayn-Dzak [30] (an area famous for its Flaming Cliffs and remains of Cretaceous mammals). The Tertiary sediments represent a channeling into the red sands of the Djadokhta [31] Formation; the channel itself is made up of clay, sandstones and conglomerates which are separated by a hiatus from the Cretaceous deposits below. The rare mammal remains are principally found in the upper part of the dark red and chocolate argillaceous sandstone. Trofimov and Chudinov (1970) have

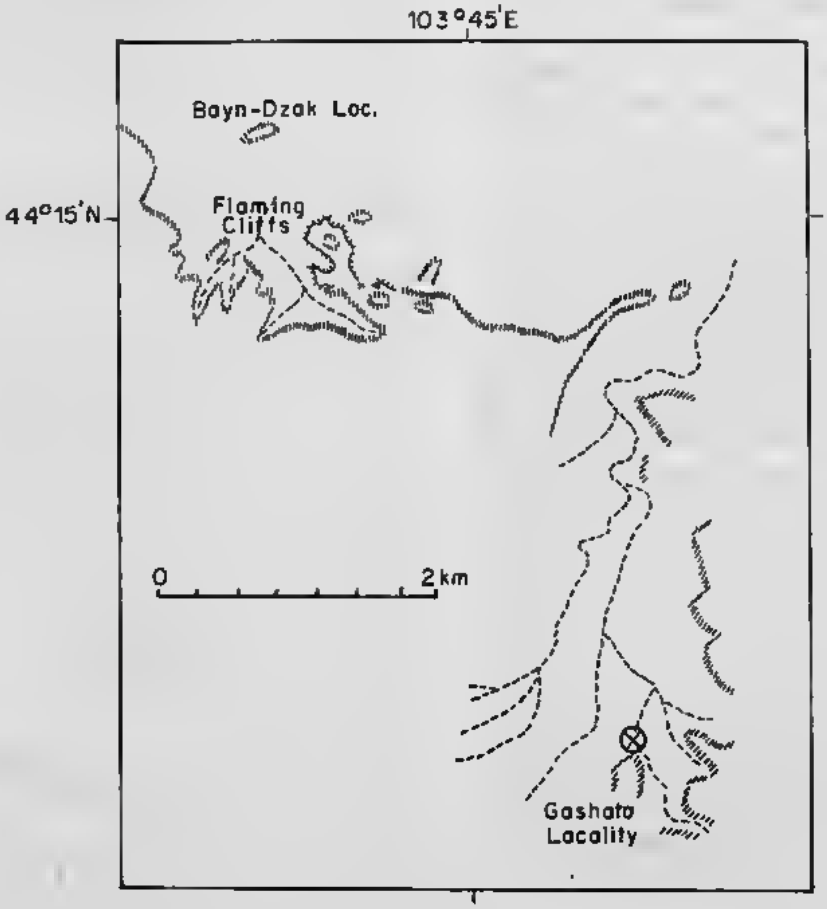


FIG. 21. — Geographic position of the Gashato locality, Mongolia. The late Cretaceous mammal locality of Bayn-Dzak is also shown. Broken lines indicate dry stream beds (sayrs). Modified from Gradzinski *et al.*, 1977.

suggested that screen washing could be employed to enrich the fauna, saying that there is no lack of water nearby.

Collecting has always been a problem at Gashato as the sediments contain few fossils. The locality was discovered in 1923 by the geologist Morris, member of the American Museum Central Asiatic Expedition; a small collection of fossil mammals was made that year and a second, and larger, collection made in 1925. The Soviet expedition of 1948 added some material to the known fauna, and the site was visited by Polish-Mongolian crews in 1963, 1964 and 1965, but the poverty of the beds resulted in few additional

28 Dalan Dzadgada = seventy springs.
29 Bulgan (= a form of Bulak) = spring.
30 Bayn-Dzak (= Bayan-Dzak) (dzak = zag = *Haloxylon*) = rich in *Haloxylon*.
31 Djadokhta Formation; a bayndzakskaya svita is sometimes mentioned as underlying the Paleocene deposits in the Gashato area, but the name Djadokhta Fm. has priority and is clearly defined (Gradzinski, Kielan-Jaworowska & Maryanska, 1977). In general, however, we prefer the term svita for the strata of Mongolia and the U.S.S.R.

Source : MNHN, Paris

specimens being found. Detailed geological studies of the locality were made in 1973 by Soviet and Mongolian workers (Zhegallo & Shevyreva, 1974, 1976; Liskun & Badamgarav, 1977) and mammalian remains were discovered higher in the section. These studies showed a great complexity of structure in the section at Gashato and the probable existence of different ages for its respective parts.

The reference section described by Zhegallo & Shevyreva is divisible into 5 parts: the lowest one (their beds 1-3) lacks paleontologic proof of its age and could be either late Cretaceous or early Tertiary; it is unnamed or sometimes questionably associated with the overlying sequence of beds 4-9. The latter is termed the Khashat Svita [32] (for example, in Devyatkin, 1981). The Gashato fauna was found in four different levels; in beds 4 and 5, in the middle of 6, and at the base of 7. Different cycles of sedimentation are represented by these beds and the top of the bed 4 has locally had up to 6 m of sediment removed. Faunistic analysis of the Khashat Svita is not possible, since early collections were not made precisely with respect to the different levels. Zhegallo & Shevyreva determined that the type specimens of *Prodinoceras martyr* and of *Phenacolophus fallax* came from bed 4, as did a specimen referred to as *Pseudictops*? sp. Above bed 4 the remains of neither *Prodinoceras* nor *Phenacolophus* have ever been discovered. Concerning the smaller mammals, one can only note that the large majority of them have been attributed to beds 5-7, and that the most abundant form is "*Palaeostylops*".

The three distinctive parts of the reference section overlying the Khashat Svita have not

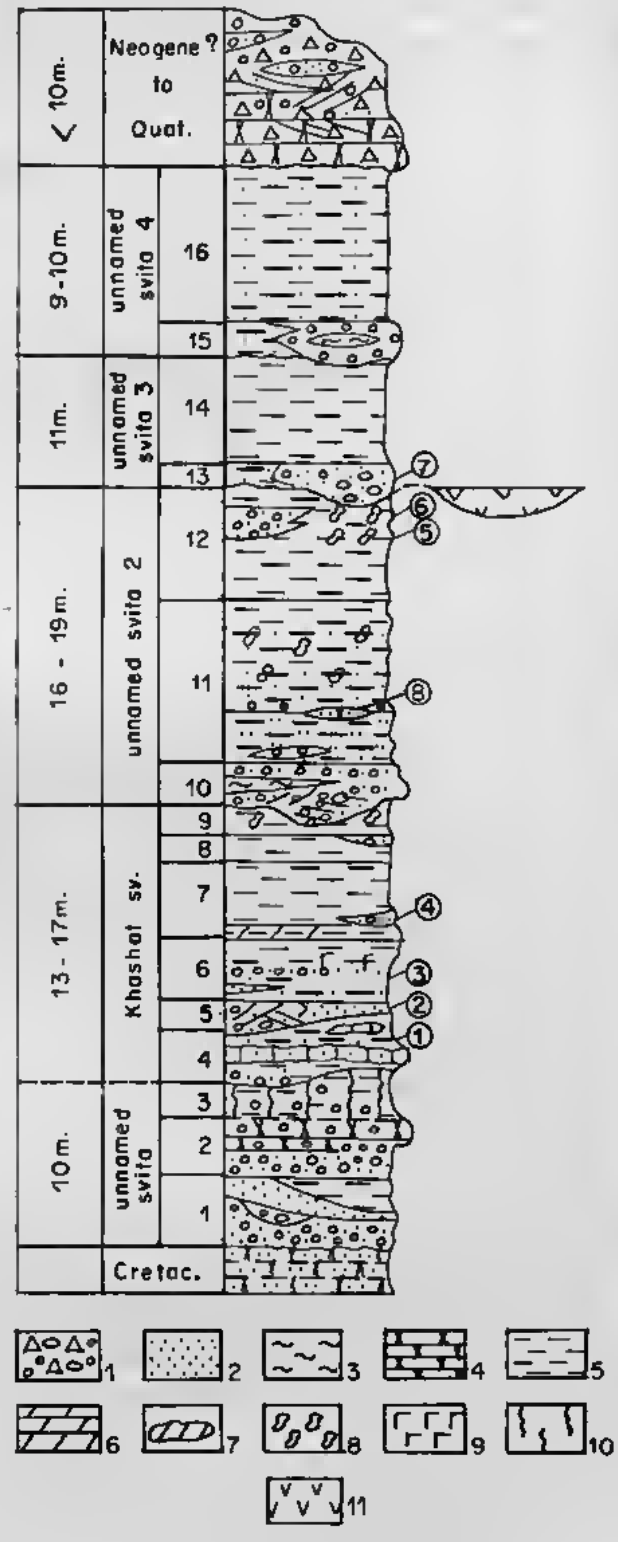


FIG. 22. — Stratigraphic section in the area of the Gashato locality, Mongolia. **1.** gravel to pebbles; **2.** sand; **3.** mudstone; **4.** cemented sand to pebbles; **5.** clay; **6.** marl; **7.** intercalations of carbonate; **8.** carbonate concretions; **9.** gypsum; **10.** signs of alteration and paleosols; **11.** basalt. Encircled numbers indicate occurrence of vertebrate fossils: 1 to 4 is the classic Gashato fauna; **5** and **6**, possible condylarth and pantodont remains; 7. the level of the type specimen of *Gomphos elkema*; **8.** other remains of *Gomphos*. For Devyatkin (1981) the Kashat Svita includes the unnamed svita 2; for Dashzeveg (pers. com., 1985) the Khashat Svita as labeled here is called the Khashat Member and the unnamed svitas 2 and 3 are included in an expanded Khashat Svita as members. Modified from Zhegallo & Shevyreva, 1976.

32 A Gashato Formation was named by Berkey & Morris (1927), but it is difficult to integrate this concept into the stratigraphy of the area today. We will use the term Khashat Svita in accordance with current usage in Mongolia.

Source : MNHN, Paris

received names; we will refer to them informally as svita 2, svita 3 and svita 4.

Svita 2, comprising beds 10-12, contains no fossils that permit its age to be established. High in bed 12, however, Zhegallo and Shevyreva found isolated limb bones which they referred with doubt to Condylarthra and Pantodonta. Erosional surfaces separate all of the svitas in the reference section, but that between the Khashat Svita and svita 2 is known to be particularly important; a hiatus of considerable duration is possible.

In svita 3 (beds 13-14) was found the type specimen of *Gomphos elkema*. Also, about 5 km west of the reference section a basalt flow is known that intercalates between svita 3 and svita 2. This basalt has been dated radioisotopically (Gabunia *et al.*, 1975) and has furnished a date of 51 $\pm$ 3 MY, but it should be noted that the decay constant used for this calculation is not the same as that used in the Occident. If such a recalculation is made (see Russell *et al.*, 1982a) a date approximating 48 MY is obtained; given the margin of error ($\pm$ 3 MY), this could indicate a date that would correspond to very late in the early Eocene, or more likely, to the middle Eocene, which would compromise the correlative value *Gomphos elkema*. Since the reliability of radiometric dates is subject to caution, it would be prudent at this time to avoid making pronouncements that risk being too dogmatic in nature.

Svita 4 (beds 15-16) differs from the svitas underlying it by structural characters and shows analogies with the sediments of the Oligocene Shand-Gol Svita.

The presence in the mammalian assemblage of a primitive uintathere, *Prodinoceras*, that was quite similar to "*Probathyopsis*" from the Tiffanian and Clark's Fork beds of North America can be taken as evidence for considering the Gashato locality as late Paleocene in age. Szalay and McKenna (1971) noted this similarity but retained the genera as distinct, remarking that minor dental differences were reinforced by differing characters in the astragali. Despite this opinion, Dashzeveg (1979c, 1982b) synonymized "*Probathyopsis*" with *Prodinoceras*; Rose (1981) also considered them as probably congeneric and a revision of the Dinocerata to the genus level by Schoch & Lucas (1985) confirmed it. Further supporting a correlative relationship with the Tiffanian and Clark's Fork beds, Dashzeveg (1979c, and in more detail, 1982a), also synonymized the North American *Arctostylops* and the Asian "*Palaeostylops*". It appears likely, then, that the lower part of the Khashat Svita is of late Paleocene age.

The presence of *Gomphos elkema* high in the section (bed 13) offers another possibility of correlation; at the locality of Tsagan-Khushu, in the Bumban Member of the Naran-Bulak Svita, *Gomphos elkema* is found associated with a typical early Eocene Holarctic assemblage (Dashzeveg, 1982a). If svita 3 is early Eocene and the Khashat Svita is late Paleocene, the limit between the two epochs occurs somewhere between the top of svita 3 and the top part of the Khashat Svita [33]. We concur with Zhegallo and Shevyreva (1976) who consider beds 4-9 (the Khashat Svita) to represent probably a short time span [34]. They cogently point out, however, that until the distribution of each taxon is known, bed by bed, all biostratigraphic conclusions concerning the Gashato fauna must be regarded as tentative. While this is certainly true for a detailed study, comparison with the better documented collections made in the Nemegt Basin at Naran-Bulak and Tsagan-Khushu indicates that, as a whole, the assemblage of the Khashat Svita corresponds to the fauna of the Naran Member of the Naran-Bulak Svita and can probably be taken as representative of the Asian late Paleocene.

Fauna of the Khashat Svita

MULTITUBERCULATA

TAENIOLABIDIDAE

— *Prionessus lucifer* Matthew & Granger, 1925
— *Sphenopsalis nobilis* Matthew, Granger & Simpson, 1928

33 *Gomphos elkema* has also been found in bed 11 of svita 2; pers. com. Dashzeveg, 1983.
34 Kowalski (in Szalay & McKenna, 1971) considers the Naran-Bulak Svita sediments also to have been deposited rapidly.

Source : MNHN, Paris

INSECTIVORA

MICROPTERNODONTIDAE — *Sarcodon pygmaeus* Matthew & Granger, 1925a
(= *Opisthopsalis vetus* Matthew, Granger & Simpson, 1929, *in* Szalay & McKenna, 1971)

FAMILY Indet. — *Praolestes nanus* Matthew, Granger & Simpson, 1929

DINOCERATA

UINTATHERIIDAE — *Prodinoceras martyr* Matthew, Granger & Simpson, 1929

ANAGALIDA

ANAGALIDAE — *Khashanagale zofiae* Szalay & McKenna, 1971
— *Khashanagale*? sp.; cited by Szalay & McKenna, 1971

PSEUDICTOPIDAE — *Pseudictops lophiodon* Matthew, Granger & Simpson, 1929

MIXODONTIA

EURYMYLIDAE — *Eurymylus laticeps* Matthew & Granger, 1925a
(= *Baenomys ambiguus* Matthew & Granger, 1925a, *in* Matthew, Granger & Simpson, 1929)

CONDYLARTHRA

MESONYCHIDAE — *Dissacus*? n. sp.; cited by Szalay & McKenna, 1971

CONDYLARTHRA?

PHENACOLOPHIDAE[35] — *Phenacoloplus fallax* Matthew & Granger, 1925a
(= *Procoryphodon primaevus* Flerov, 1957a, *in* Simons, 1960)

NOTOUNGULATA

ARCTOSTYLOPIDAE — *Arctostylops iturus* (Matthew & Granger, 1925a) Dashzeveg, 1979c
(= *Palaeostylops iturus* Matthew & Granger, 1925a)
— *Arctostylops macrodon* (Matthew, Granger & Simpson, 1929), Dashzeveg, 1979c
(= *Palaeostylops macrodon* Matthew, Granger & Simpson, 1929)

ORDER Indet.

FAMILY Indet. — *Hyracolestes ermineus* Matthew & Granger, 1925a

FIG. 23. — Sketch map of southern Mongolia showing the position of the following localities: **1**. Gashato; **2** Bayn-Dzak (Cretaceous); **3**. Tsagan-Khushu; **4**. Naran-Bulak; **5**. Ulan-Bulak; **6**. Khaychin-Ula; **7**. Tsakhir; **8**. Khongil-Tsav; **9**. Ulan-Khureh. Modified from Gradzinski *et al.*, 1977.

35 This family was referred to the Embrithopoda by McKenna and Manning (1977), to the Condylarthra by Zhang (1978), and to the Pantodonta by Chow and Wang (1979).

Source : MNHN, Paris

Lat. 43° 28′ N, approx.
Long. 100° 27′ E, approx.

Fig. 1, n° 12, 13, 14

MONGOLIA

OMONO GOBI PROVINCE

Nemegt Depression

Naran-Bulak Svita

Zhigden and Naran Members — **late Paleocene**

Localities: Naran-Bulak, Tsagan-Khushu, Ulan-Bulak (= Aguy-Dats-Bulak) and Khongil-Tsav

The Nemegt [36] Basin forms the western part of a large intermontane depression (with parallel sides) in the southern part of the Gobi Altay. It is 35-45 km wide and can be taken to be about 115 km long in an east-west direction (between Tsum-Tsees-Khayrkhan [37] Mountain and the salt lake at the site of Gurvan-Tes village, as delimited by Gradzinski *et al.*, 1968/1969). However, the eastern extremity is open and morphologically it extends another 150 km eastward. The

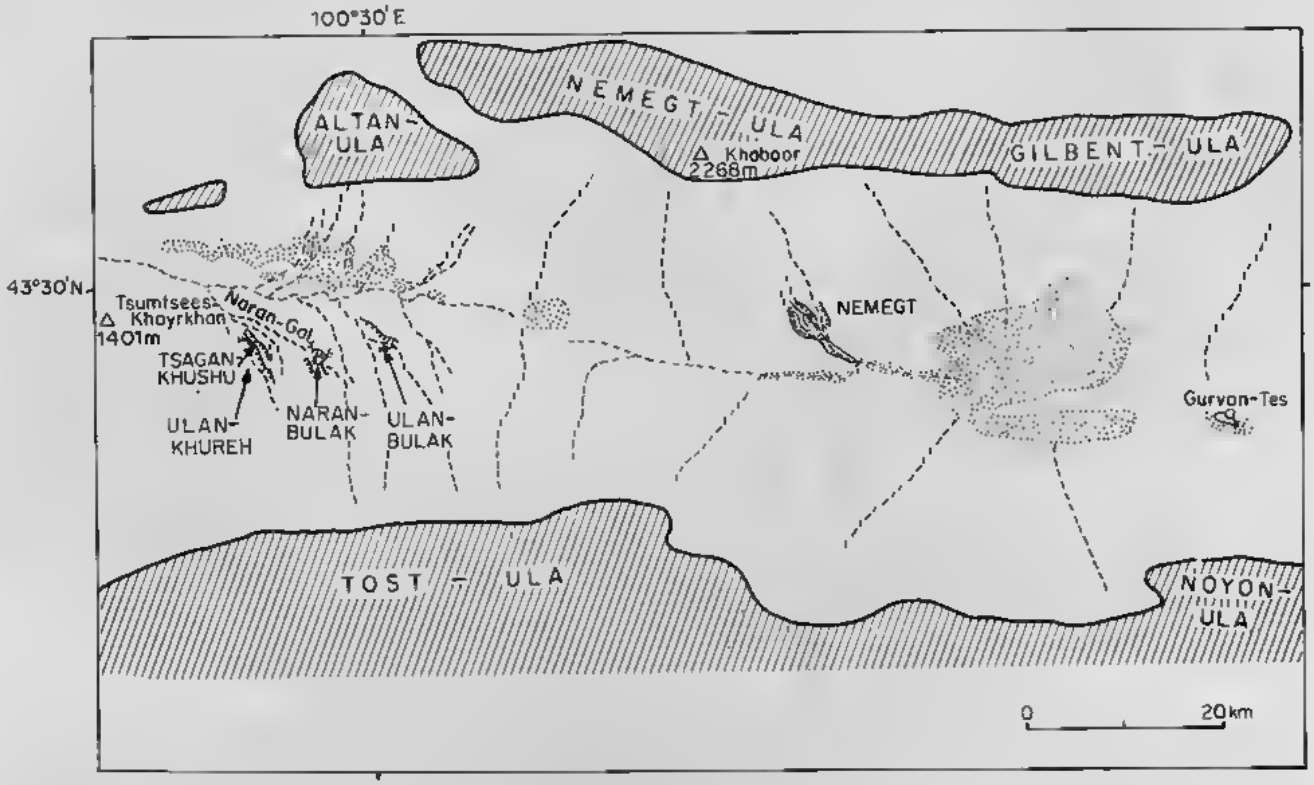


FIG. 24. — Sketch map of the Nemegt Basin, showing the Paleocene localities of Naran-Bulak and Ulan-Bulak, the Paleocene-Eocene section at Tsagan-Khushu and the Oligocene site of Ulan-Khureh. Modified from Gradzinski *et al.*, 1968/1969.

36 Nemegt (= Nemeget as spelled in Mongol, but pronounced Nemegt) = added on. The spellings of Mongolian words given here are transliterations mostly from Russian sources and do not conform to accepted spellings of the Mongol language.

37 Tsum-Tsees-Khayrkhan = blessed and harmonious?.

Source : MNHN, Paris

bordering mountains are made up of a complex of mainly Paleozoic rocks. Erosional incisions in the pediment, which slopes south toward the axis of the basin, reveal sections of late Cretaceous and early Tertiary sediments. The Paleogene rocks occupy the central part of the basin, disappearing in the outcrops of the southwest border and extending nearly 20 km in an east-west direction. These deposits, overlying the pink beds of the late Cretaceous Nemegt Svita, are divided into 3 distinct series, called the lower red beds, the white beds and the upper red beds. This sequence permitted correlation between the localities of Naran-Bulak [38], Tsagan-Khushu [39] and Ulan-Bulak [40] (= Aguy-Dats-Bulak) [41]. A distance of about 12 km separates the Tsagan-Khushu exposures in the west from those at Ulan-Bulak in the east; the Naran-Bulak locality is situated about midway between them.

The main group of exposures of the Naran-Bulak Svita [42] at the locality of Naran-Bulak extends on both sides of the middle section of the Naran-Gol [43]. The site was discovered during the Mongolian Paleontological Expedition of the USSR Academy of Sciences in 1946; further work was done here by the expeditions of 1948-1949. The Polish-Mongolian Expedition collected in the locality in 1963 and, more intensively, in 1964; in 1970-1972 further collecting was done by the Soviet-Mongolian Paleontological Expeditions.

The Naran-Bulak spring is situated high above the Naran-Gol; beneath it the slope is covered by bushy grass, forming a bright green spot that is

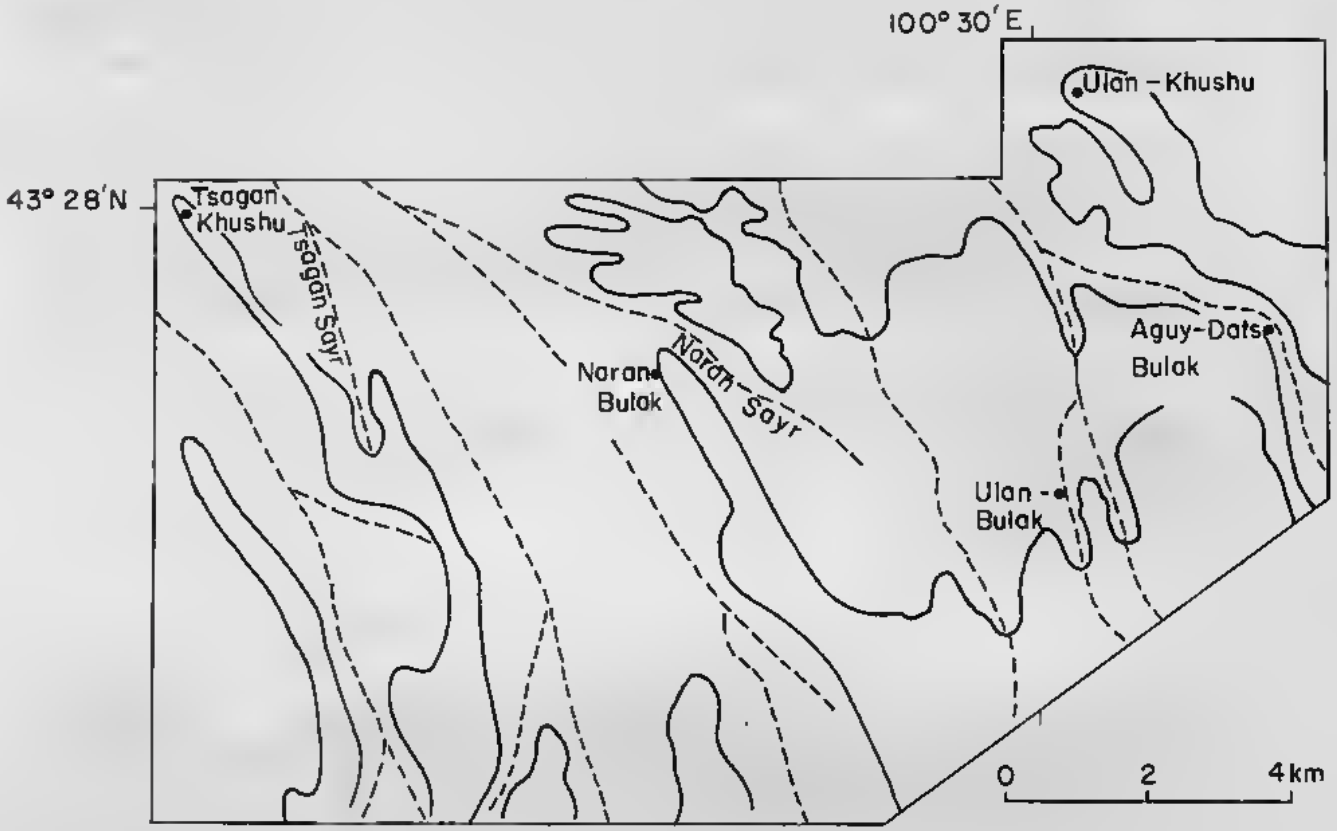


FIG. 25. — Detailed sketch map of the Nemegt Depression containing the principal Paleogene fossil localities. Modified from Badamgarav & Reshetov, 1985.

38 Naran-Bulak (= Naran-Dats) = sunshine springs, or sunny springs.
39 Tsagan-Khushu = white promontory.
40 Ulan-Bulak = red springs.
41 Aguy-Dats-Bulak = a spring coming from a grotto.
42 A Naran-Bulak Formation was proposed by Dashzeveg & McKenna (1977), but consistent with current usage in Mongolia we prefer the term svita.
43 gol = an intermittent stream bed.

Source : MNHN, Paris

visible for many kilometers. The Tertiary sediments here rest discordantly on the late Cretaceous Nemegt Svita and their contact is exposed in the lower part of the Naran-Gol section. These strata show considerable lithological variation in both horizontal and vertical profiles. The upper red beds, consisting mainly of red and often sandy mudstones, are separated from the overlying (in the Bugin-Tsav Basin) Khaychin Svita by an erosional unconformity.

The biostratigraphy of the Naran-Bulak Svita was treated in detail by Dashzeveg and McKenna (1977) and Dashzeveg (1982a). The bottom member of the svita, called the Zhigden Member [44],

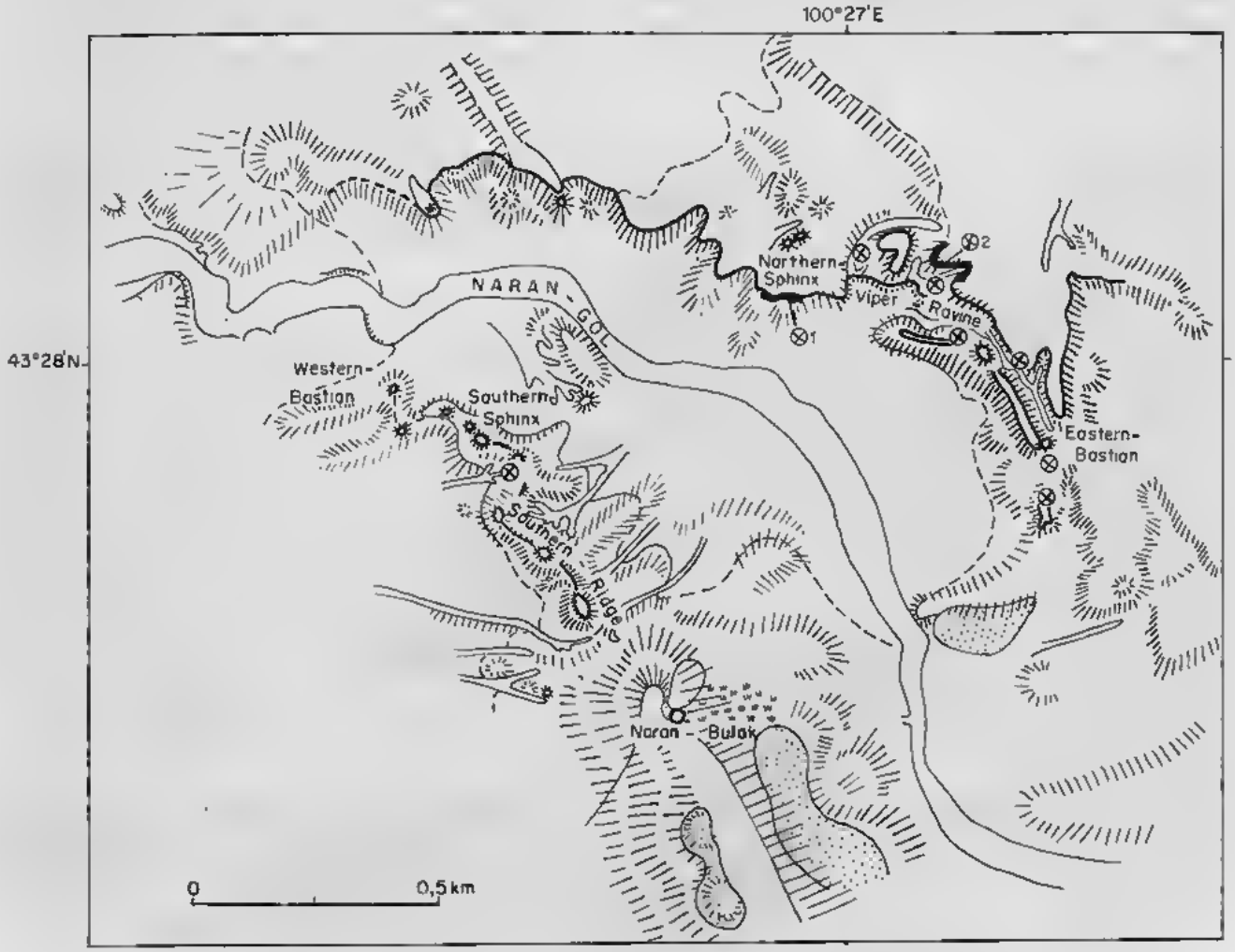


FIG. 26. — Map of the locality of Naran-Bulak. Areas where Paleogene vertebrates have been found are indicated by encircled X's. The Bumban Member is absent in this region. The principal collecting sites (in the Naran Member) are indicated by heavy black lines at 1 (in the lower level) and at 2 (in the upper level). Modified from Gradzinski *et al.*, 1968/1969.

is made up of nearly uniform red sandstones with lenses of fine gravel. A complete section of this member crops out in the western part of the Tsagan-Khushu area, where its thickness attains about 27 m. This thickness decreases from west to east and north of Ulan-Bulak the member practically disappears. The Zhigden fauna comes from the upper part of the member and was collected on both sides of the Naran stream, close to Naran spring; *Archaeolambda planicanina*, *Prodinoceras martyr*, and *Arctostylops* sp. have been identified so far. At the Tsagan-Khushu locality, a new site high in the Zhigden Member, called Quarry 3, was also discovered by

44 Zhigden = gooseberry.

Source : MNHN, Paris

Dashzeveg in 1984. It is about 300 m north of the classic early Eocene Quarry 1 site. The bone-bearing lens of red sandy clay has a thickness of about 1 m and has produced undescribed mixodonts, *Arctostylops* and *Ernanodon* (Dashzeveg, pers. com., 1986).

The Naran Member, the "white beds" of previous authors, is represented by a 30 m thick series of white sandstones and clays with marly stringers; an erosional discordance separates it from the underlying Zhigden Member. Dashzeveg distinguishes two levels in it: one that is alluvial in nature and the other lacustrine. *Prodinoceras martyr, Archaeolambda planicanina* and *Pachyaena nemegetica* typify this level, with the remains of *Arctostylops macrodon, Eurymylus laticeps* and *Pseudictops lophiodon* being more rare. At the base of the lacustrine beds, in outcrops north of Naran-Bulak, *Arctostylops, Eurymylus*, and *Pseudictops* are abundant; from

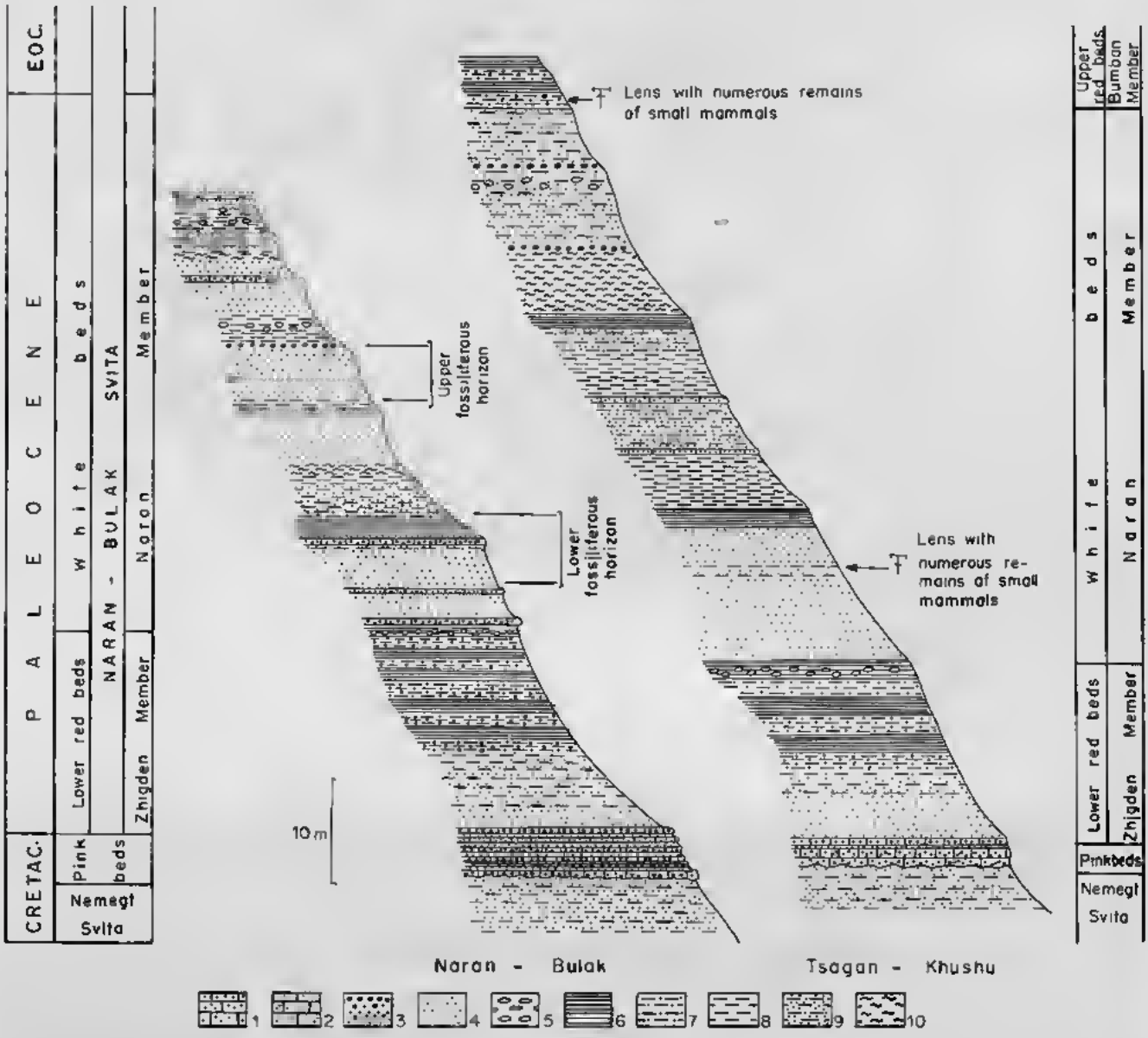


FIG. 27. — Geological profiles of Paleogene deposits at the Naran-Bulak and Tsagan-Khushu localities. **1**. conglomerate; **2**. sandstone; **3**. gravels; **4**. sand; **5**. concretions; **6**. mudstone or siltstone; **7**. mudstone or mud with gravels; **8**. silt; **9**. sands with silt intercalations; **10**. clay. Modified from Gradzinski *et al.*, 1968/69 (the latter do not use the term svita). Mammalian remains were found in the upper part of the Zhigden Member by the Soviet-Mongolian Paleontological Expedition of 1983.

Source : MNHN, Paris

the same level are also known *Dissacus indigenus, Oxyaena* sp., cf. "*Sinopa*" and *Prionessus lucifer*. In the upper part of the lacustrine beds, at Tsagan-Khushu, has been found *Coryphodon tsaganensis*.

The two principal fossiliferous levels in the Naran Member, cited by the Polish-Mongolian Expeditions (Gradzinski *et al.*, 1968/1969) and by Dashvezeg (1982a), are also found in the section at Tsagan-Khushu. The time difference that separates them is as yet undetermined, but is probably slight. A major interest of the Tsagan-Khushu locality has been the discovery in the Bumban Member of a significant number of genera that are characteristic of the early Eocene in Europe and North America (see Eocene chapter).

The third important locality in the Naran-Bulak area is that called Ulan-Bulak but now referred to as Aguy-Dats-Bulak (by Reshetov, pers. com., 1984). Reshetov is of the opinion that in the stream bed valley of Ulan-Bulak only Cretaceous sediments are present; the late Paleocene deposits crop out in the next sayr (or, dry stream bed) to the northeast, which bears the name of Aguy-Dats-Bulak. Reshetov proposes that the name accorded to the fossil locality be changed in consequence, but Dashzeveg (pers. com., 1985) does not agree. So far, only *Archaeolambda planicanina, Prodinoceras martyr* and *Pachyaena nemegetica* are known, representing the fauna of the Naran Member.

Another locality, Khongil-Tsav (or Unegen-Khongil)[45] is situated about 30 km northeast of Ulan-Bulak, close to the northern edge of the Nemegt Basin. Only the Naran Member of the Naran-Bulak Svita is present here, but both the lacustrine and alluvial facies of it are represented. The upper and lower contacts of this member are not visible; Gobi Conglomerate forms the covering surface. *Prodinoceras martyr* and *Pachyaena nemegetica* have been collected at this site.

A study of the lithostratigraphy and taphonomy of the Paleogene sediments of the Naran-Bulak region was made by Shishkin (1975).

In the years following the discovery of the richly fossiliferous levels of the Naran-Bulak Svita, there was much discussion concerning the age of the collected mammals and their relationship to those found at Gashato; opinions alternated between the late Paleocene and the early Eocene. Until recently (for example, Dashzeveg, 1982a) the collections from both localities had been lumped and each one considered as representing a single fauna. It is now evident that there exists, both at Gashato and in the Nemegt Basin localities of the Naran-Bulak Svita, a Holarctic early Eocene assemblage that overlies a largely endemic late Paleocene fauna. It is not possible to speak of one or the other locality as if it represented a single age.

Fauna of the Naran-Bulak Svita (Zhigden and Naran Members)
(*, Naran-Bulak; **, Tsagan-Khushu; ***, Ulan-Bulak (= Aguy-Dats-Bulak); ****, Khongil-Tsav)
(N, Naran Member; Z, Zhigden Member)

MULTITUBERCULATA		
	TAENIOLABIDIDAE	
N	*	*Prionessus lucifer*? Matthew & Granger, 1925a; cited by Gradzinski *et al.*, 1968/1969
Z	*	*Prionessus lucifer* Matthew & Granger, 1925; cited by Badamgarav & Reshetov, 1985
Z	*	cf. *Prionessus lucifer* Matthew & Granger, 1925a; cited by Badamgarav & Reshetov, 1985
N	*	*Prionessus* sp.; cited by Badamgarav & Reshetov, 1985
INSECTIVORA		
	MICROPTERNODONTIDAE	* *Sarcodon* sp.; cited by Dashzeveg & McKenna, 1977
	FAMILY indet.	** cf. *Praolestes nanus* Matthew, Granger & Simpson, 1929; cited by Badamgarav & Reshetov, 1985

45 Khongil-Tsav = canyon cliff.
Unegen-Khongil = fox canyon.

Source : MNHN, Paris

PANTODONTA		
PANTOLAMBDODONTIDAE		
Z, N	***, **, *	*Archaeolambda planicanina* Flerov, 1952a; cited by Gradzinski *et al.*, 1969/1969; cited elsewhere by Badamgarav & Reshetov, 1985 (= *Haplolambda planicanina* (Flerov, 1952a) Simons, 1960; denied by Kielan-Jaworowska, 1968-1969)
CORYPHODONTIDAE		
N	**, *	*Coryphodon tsaganensis* Reshetov, 1976
DINOCERATA		
UINTATHERIIDAE		
Z, N,	****, *	*Prodinoceras martyr* Matthew, Granger & Simpson, 1929; cited by Dashzeveg, 1982a
N	***	(= *Mongolotherium efremovi* Flerov, 1957b, *in* Dashzeveg, 1982b)
N	***	(= *Mongolotherium plantigradum* Flerov, 1952b, *in* Dashzeveg 1982b; cited by Flerov, 1957b)
N	**	*Prodinoceras* sp.; cited by Badamgarav & Reshetov, 1985
ANAGALIDA		
PSEUDICTOPIDAE		
N, Z	**, *	*Pseudictops lophiodon* Matthew, Granger & Simpson, 1929; cited by Gradzinski *et al.*, 1968/1969; cited elsewhere by Badamgarav & Reshetov, 1985
	*	(= *Pseudictops arilophodon* Trofimov, 1952, *in* Sulimski, 1968/1969)
MIXODONTIA		
EURYMYLIDAE		
N, Z	***	*Eurymylus laticeps* Matthew & Granger, 1925a; cited by Gradzinski *et al.*, 1968/1969; cited elsewhere by Badamgarav & Reshetov, 1985
Z	*	cf. *Eurymylus* sp.; cited by Badamgarav & Reshetov, 1985
Z	**	Eurymylidae indet.; cited by Badamgarav & Reshetov, 1985
CREODONTA		
OXYAENIDAE		
N	*	*Oxyaena* sp.; cited by Dashzeveg, 1982a
HYAENODONTIDAE		
N	*	cf. *Sinopa* sp.; cited by Dashzeveg, 1982a
CONDYLARTHRA		
MESONYCHIDAE		
N, Z	**, *	*Dissacus indigenus* Dashzeveg, 1976a; cited elsewhere by Badamgarav & Reshetov, 1985
N	****, ***, **, *	*Pachyaena nemegetica* Dashzeveg 1976a; cited elsewhere by Badamgarav & Reshetov, 1985 (= "*Mesonyx obtusidens*", Cope, 1872; cited by Gromova, 1952a, *in* Szalay & Gould, 1966)
CONDYLARTHRA?		
N PHENACOLOPHIDAE?		cf. Phenacolophidae; cited by Badamgarav & Reshetov, 1985
EDENTATA?		
ERNANODONTIDAE		
Z	*	cf. *Ernanodon* sp.; cited by Badamgarav & Reshetov, 1985
NOTOUNGULATA		
ARCTOSTYLOPIDAE		
?		*Arctostylops iturus* (Matthew & Granger, 1925a), Dashzeveg, 1979c
Z, N	**, *	(= *Palaeostylops iturus* Matthew & Granger, 1925a; cited by Gradzinski *et al.*, 1968/1969); cited elsewhere by Badamgarav & Reshetov, 1985

Source : MNHN, Paris

N ***, **, * *Arctostylops macrodon* (Matthew, Granger & Simpson, 1929), Dashzeveg, 1976c
(= *Palaeostylops macrodon* Matthew, Granger & Simpson, 1929; cited by Dashzeveg & McKenna, 1977; cited elsewhere by Badamgarav & Reshetov, 1985)

Z * *Arctostylops* sp.; cited by Dashzeveg, 1982a

ORDER Indet.

Z DIDYMOCONIDAE Indet.; opinion of authors (= Miacidae indet.; cited by Badamgarav & Reshetov, 1985

Lat. 44° N, approx.
Long. 100° E, approx.

Fig. 1, n° 9

MONGOLIA

ZAALTAY GOBI PROVINCE

Bugin-Tsav Basin

Naran-Bulak Svita **late Paleocene**

Locality: Khaychin-Ula I

In the Bugin-Tsav Basin at the Khaychin-Ula I area to the north of the Nemegt Basin, mammalian fossils were found in the lower part of a section that was considered to be an extension of the Naran-Bulak Svita. The discovery was made by the Soviet-Mongolian Paleontological Expedition of 1969; the remains of *Pastoralodon trofimovi* and « *Mongolotherium* » were identified by Flerov & Dashzeveg (1974), and *Prodinoceras* sp. and *Barylambda* sp. were cited by Dashzeveg in Devyatkin (1981).

As these forms better typify a Paleocene assemblage than one of Eocene age, it is supposed that the beds that produced them are lateral equivalents to the Naran and/or Zhigden Members of the Naran-Bulak Svita.

At the time of its discovery and initial publication, this site was referred to as comprising part of the Khaychin-Ula II region. Badamgarav and Reshetov (1985) consider it as more appropriately part of the Khaychin-Ula I area (see fig. 70). We follow their opinion.

Fauna of the Naran-Bulak Svita at Khaychin-Ula I

PANTODONTA

PANTOLAMBDODONTIDAE — *Archaeolambda planicanina* Flerov, 1952a; cited by Badamgarav & Reshetov, 1965

PASTORALODONTIDAE — *Pastoralodon trofimovi* (Flerov & Dashzeveg, 1974) Lucas, 1982 (= *Archaeolambda trofimovi* Flerov & Dashzeveg, 1974)

BARYLAMBDIDAE — *Barylambda* sp.; cited by Dashzeveg in Devyatkin, 1981

DINOCERATA

UINTATHERIIDAE — *Prodinoceras* sp.; cited by Dashzeveg in Devyatkin, 1981 (= *Mongolotherium* sp.; cited by Flerov & Dashzeveg, 1974)

— *Prodinoceras martyr* Matthew, Granger & Simpson, 1929; cited by Badamgarav & Reshetov, 1985

MIXODONTIA Indet.; cited by Dashzeveg, pers. com., 1985

Source : MNHN, Paris

LATE PALEOCENE

Composite list

(**Chi**: Chijiang Basin; **Ga**: Gashato; **KU**: Khaychin-Ula I; **Nan**: Nanxiong Basin; **NB**: Naran-Bulak; **Nom**: Nomogen; **Qia**: Qianshan Basin; **Tan**: Tantou Basin; **Tur**: Turpan Basin; **Xuan**: Xuancheng Basin)

MULTITUBERCULATA

TAENIOLABIDIDAE

Nom, Ga, NB — *Prionessus lucifer*
NB — *Prionessus lucifer*?
NB — cf. *Prionessus lucifer*
NB — *Prionessus* sp.
Nom, Ga — *Sphenopsalis nobilis*
Nom — *Sphenopsalis*? sp.

LAMBDOPSALIDAE

Nom — *Lambdopsalis bulla*
Tur — Multituberculata indet.

INSECTIVORA

MICROPTERNODONTIDAE

Nom, Ga — *Sarcodon pygmaeus*
NB — *Sarcodon* sp.
Chi — Insectivora indet.

PROTEUTHERIA

FAMILY indet.

Ga — *Praolestes nanus*
NB — cf. *Praolestes nanus*

PRIMATES?

ADAPIDAE?

NAN — *Petrolemur brevirostre*

PANTODONTA

PANTOLAMBDODONTIDAE

Chi — *Archaeolambda dayuensis*
Qia — *Archaeolambda tabiensis*
NB, KU — *Archaeolambda planicanina*
Chi, Tur — *Archaeolambda* cf. *planicanina*
Xuan — *Archaeolambda yangtzeensis*
Chi, Nan — *Archaeolambda* sp.
Chi, Tur — *Archaeolambda speciosa*
Nan — *Archaeolambda zhuguikengensis*
Tan — Pantolambdodontidae indet.

HARPYODIDAE

Chi — *Harpyodus decorus*

PASTORALODONTIDAE

Nan — *Altilambda pactus*
Nan — *Altilambda minor*
Nan — *Altilambda* sp.
Nom — *Pastoralodon lacustris*
Nom — *Pastoralodon convexus*
Nom — *Pastoralodon haliutensis*
KU — *Pastoralodon trofimovi*
Tan — Pastoralodontidae indet.

Source : MNHN, Paris

CORYPHODONTIDAE

NB — *Coryphodon tsaganensis*

BARYLAMBDIDAE

KU — *Barylambda* sp.

DINOCERATA

UINTATHERIIDAE

Chi — *Prodinoceras lacustris*
Tur — *Prodinoceras turfanensis*
Tur — *Prodinoceras diconicus*
Ga, NB, KU — *Prodinoceras martyr*
KU, NB — *Prodinoceras* sp.
Tur — *Prodinoceras primigenum*
Tur — *Prodinoceras simplum*
Tan — Dinocerata indet.

ANAGALIDA

ANAGALIDAE

Qia — *Hsiuannania tabiensis*
Xuan — *Hsiuannania maguensis*
Chi — *Hsiuannania minor*
Qia — *Hsiuannania* sp.
Nan — cf. *Huaiyangale leura*
Ga — *Kashanagale zofiae*
Ga — *Kashanagale*? sp.

PSEUDICTOPIDAE

Qia — *Allictops inserrata*
Nan — *Halticlops mirabilis*
Nan — *Halticlops meilingensis*
Tur — *Pseudictops chaii*
Nom, Ga, NB — *Pseudictops lophiodon*
Chi — *Pseudictops*? *tenuis*
Tan — Pseudictopidae indet.

FAMILY Indet.

Nan — *Interogale datangensis*

MIXODONTIA

EURYMYLIDAE

Qia — *Heomys orientalis*
Ga, NB — *Eurymylus laticeps*
NB — cf. *Eurymylus* sp.
Tur, NB — Eurymylidae indet.

MIMOTONIDAE

Qia — *Mimotona robusta*
Qia — *Mimotona wana*
Nom — *Mimotona borealis*
KU — Mixodontia indet.

CREDONTA

OXYAENIDAE

NB — *Oxyaena* sp.

HYAENODONTIDAE

NB — cf. *Sinopa* sp.

CONDYLARTHRA

PERYPTICHIDAE

Chi — *Pseudanisonchus antelios*

Source : MNHN, Paris

HYOPSODONTIDAE

Chi — gen. & sp. nov.

MESONYCHIDAE

Xuan — *Dissacus magushanensis*
NB — *Dissacus indigenus*
Nom, Ga — *Dissacus*? sp.
Nan — *Yantanglestes datangensis*
Chi — *Jiangxia chaotoensis*
Chi — *Hapalodectes*? sp.
NB — *Pachyaena nemegetica*
Nan — *Pachyaena*? sp.
Nom — *Plagiocristodon serratus*
Tur — Mesonychidae indet.

CONDYLARTHRA?

PHENACOLOPHIDAE

Nan — *Minchenella grandis*
Nan — *Yuelophus validis*
Chi — *Ganolophus lanikenensis*
Tur — *Tienshanilophus subashiensis*
Tur — *Tienshanilophus lianmuqinensis*
Tur — *Tienshanilophus shengjinkouensis*
Ga — *Phenacolophus fallax*
NB — cf. Phenacolophidae
Nan — Phenacolophidae gen. & sp. nov.

EDENTATA?

ERNANODONTIDAE

Nan — *Ernanodon antelios*
NB — cf. *Ernanodon* sp.

NOTOUNGULATA

ARCTOSTYLOPIDAE

Qia — *Sinostylops promissus*
Xuan — *Sinostylops progressus*
Chi — *Asiostylops spanios*
Chi — *Allostylops periconotus*
Nom, Ga, NB — *Arctostylops iturus*
Nom, Ga, NB — *Arctostylops macrodon*
NB — *Arctostylops* sp.
Nan — Arctostylopidae indet.

ORDER Indet.

DIDYMOCONIDAE

Chi — *Archaeoryctes notialis*
NB — Didymoconidae indet.

ORDER Indet.

FAMILY Indet.

Qia — *Obtususdon hanhuaensis*
Qia, Ga — *Hyracolestes ermineus*
Xuan — *Wanotherium xuanchengensis*

Source : MNHN, Paris

Lat. 43° 8′ N
Long. 111° 35′ E

Fig. 2, n° 3

CHINA
Nei Mongol Autonomous Region
(Inner Mongolia)

Nomogen? Fm. **late Paleocene-early Eocene**

Locality: Bayn Ulan

During the field seasons of 1976 and 1977 a team from the IVPP, working with mapping geologists in the region between Erenhot [1] and Sisiwang, found an assemblage of fossil mammals made up in large part of members of the endemic fauna known at Gashato and at Naran-Bulak. The locality is situated at the northern foot of the Nomogen Mesa, about 60 km north of the Nomogen site.

At Bayn Ulan [2] the Arshanto Formation overlies the mammal producing beds; the sediments of both formations are very similar in aspect and are distinguished only by their fossil content. It was thought for a time that the Nomogen fauna came from a level below that containing the Bayn Ulan fauna; at the Bayn Ulan locality the two levels appeared to be sometimes separated by a layer of green clay that is up to 1 m thick. All levels are constituted by essentially the same red sandy clays and lithologically there is little to differentiate between them. The lacustrine sandy clays and silts yielding the Bayn Ulan assemblage are 7 m thick at the locality, but become thicker to the northeast and reach about 30 m in the Camp Margetts area. So far, it has not been possible to correlate directly the localities of Bayn Ulan and Nomogen by surface observation as they are separated by a considerable distance.

While the fauna listed below is from the Ulan locality, there are three localities to the north that yielded fossil mammals of the same age: Fuhoborho, Ulanborho and Subon (= Subeng). At the latter were found *Arctostylops, Pseudictops*, multituberculates, a primitive uintathere and dermopteran teeth. None of these have yet been described.

The age of the Bayn Ulan fauna is probably close to that of Nomogen and, in consequence, close to that of Gashato. But the presence of perissodactyls perhaps referable to *Lambdotherium* and *Heptodon* can be taken as evidence for a slightly younger age.

Fauna of the Nomogen? Fm. at Bayn Ulan
(all taxa cited by Zhai, manuscript, 1981)

MULTITUBERCULATA
- Taeniolabididae
  - — *Prionessus lucifer* Matthew & Granger, 1925a

PANTODONTA
- Pastoralodontidae
  - — *Pastoralodon lacustris* Chow & Qi, 1978, V.P. (2)

DINOCERATA
- Uintatheriidae
  - — *Prodinoceras martyr* Matthew, Granger & Simpson, 1929 (= *Mongolotherium efremovi* Flerov, 1957b, *in* Dashzeveg, 1982b; cited by Zhai, MS)
  - — *Prodinoceras* sp., *in* Schoch & Lucas, 1985 (= *Pyrodon* sp.; cited by Zhai, MS)

1 Erenhot = Erhlien = Eren City (not Iren Dabasu = Iren sali marsh).
2 Bayn Ulan (= Bayan Ulan) = rich red.

Source : MNHN, Paris

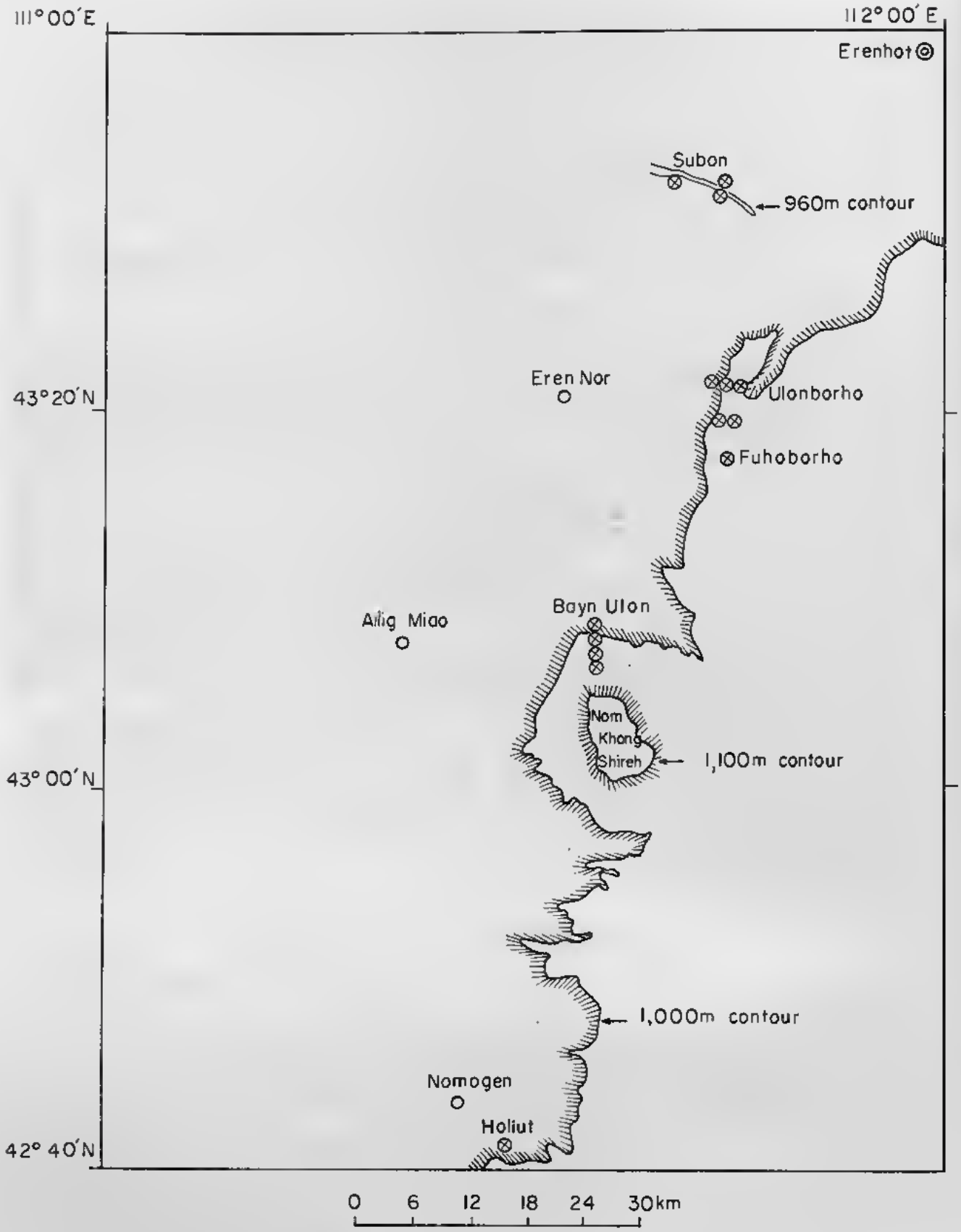


FIG. 28. — Sketch map of the fossil mammal localities in the Nom Khong Shireh region, Nei Mongol. The multiplicity of fossil locality symbols for several sites here indicates that material was discovered in more than one level and thus represents more than one age, as at Bayn Ulan where four faunas were found in four different formations. From Zhai, manuscript, 1981.

Source : MNHN, Paris

ANAGALIDA
PSEUDICTOPIDAE — *Pseudictops lophiodon* Matthew, Granger & Simpson, 1929
MIXODONTIA
MIMOTONIDAE — *Mimotona borealis* Chow & Qi, 1978, V.P. (2)
CONDYLARTHRA
MESONYCHIDAE — *Plagiocristodon serratus* Chow & Qi, 1978, V.P. (2)
— *Pachyaena* sp.
NOTOUNGULATA
ARCTOSTYLOPIDAE — *Arctostylops iturus* (Matthew & Granger, 1925a) Dashzeveg, 1979c (= *Palaeostylops iturus* Matthew & Granger, 1925a)
— *Arctostylops macrodon* (Matthew, Granger & Simpson, 1929) Dashzeveg, 1979c (= *Palaeostylops macrodon* Matthew, Granger & Simpson, 1929)
PERISSODACTYLA
BRONTOTHERIIDAE — *Lambdotherium*? sp.
HELATIDAE — *Heptodon*? sp.

Lat. 32° 27′ N
Long. 118° 25′ E
(Lai'an Town)

Fig. 2, n° 15

CHINA
ANHUI PROVINCE
Laian District

Zhangshanji Fm. **early Eocene**
Locality: Laian

In 1974 regional field geologists and members of the IVPP discovered fossils in early Tertiary sediments 8 km northeast of Laian, Anhui, and not far from the city of Nanjing (Jiangsu). This sedimentary series is divided into two units of which the upper one, the Zhangshanji [3] Formation, furnished the fossils.

The Zhangshanji Formation consists of red sandstone and sandy clay and overlies the Shunshanji [4] Formation, which is made up of gray white marls, green sands and red sandy clays. The latter is presumed to be Paleocene, but this is not certain.

The age of the Zhangshanji Formation can be determined as early Eocene based on the comparison of the eurymylid with that from the early Eocene of the Turpan Basin (Xinjiang) Since the latter fauna contains *Coryphodon*, *Heptodon*, and *Hyopsodus*, its age is well established.

Fauna of the Zhangshanji Fm.

MIXODONTIA
EURYMYLIDAE — *Rhombomylus laianensis* Zhai *et al.*, 1976, V.P. (2)

3 Zhangshanji = Zhang (family name) hill market.
4 Shunshanji = hill named in honor of Shun (a legendary monarch) market.

Source : MNHN, Paris

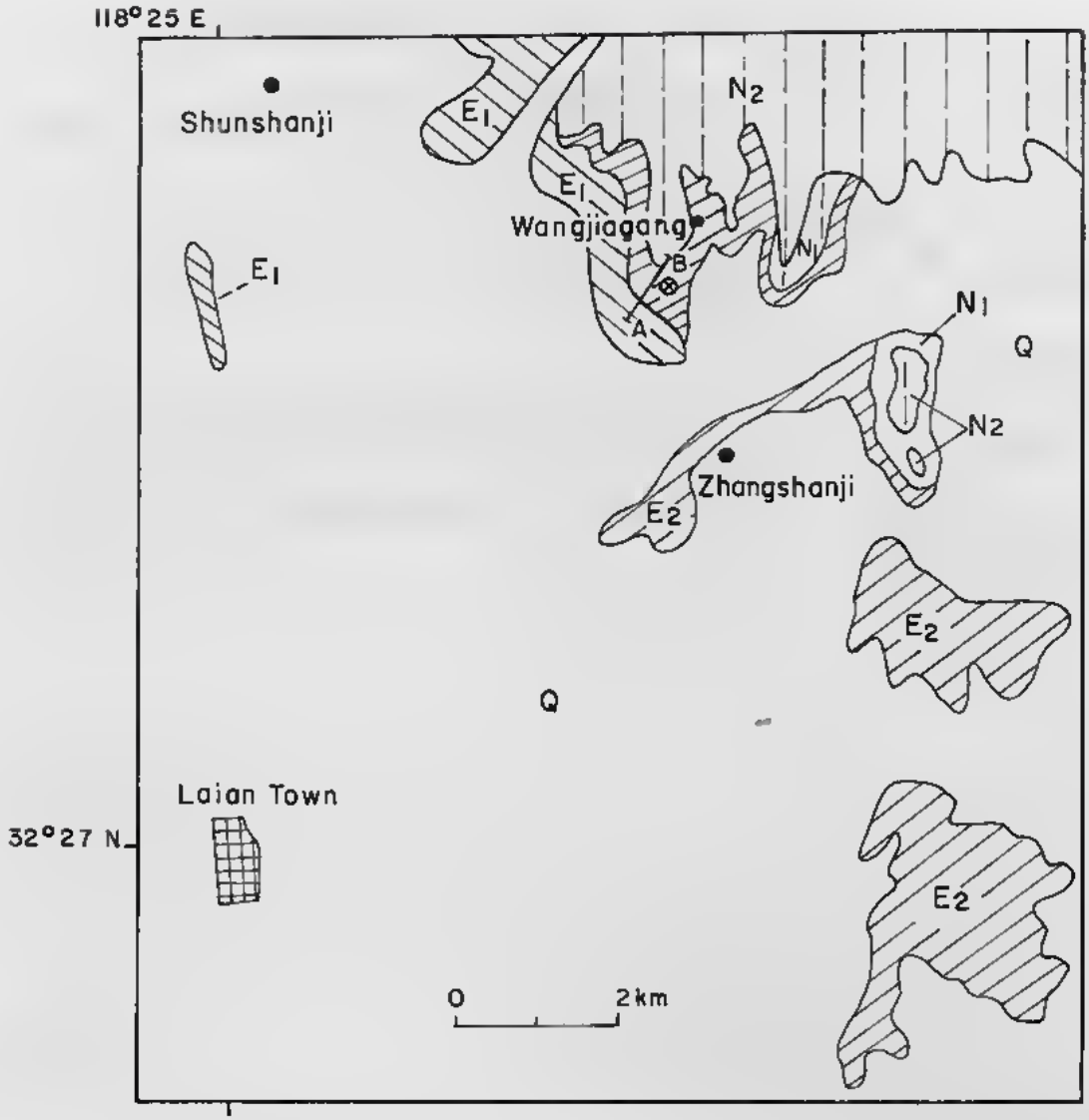


FIG. 29. — Outcrop map of the Tertiary sediments of Laian County, Anhui. E_1, Paleocene Shunshanji Fm.; E_2, early Eocene Zhangshanji Fm.; N_1, Miocene Huaguoshan Fm.; N_2, Pliocene Huanggang Fm. (basalt); Q, Quaternary. Modified from a map provided by Yu Zheng-jiang.

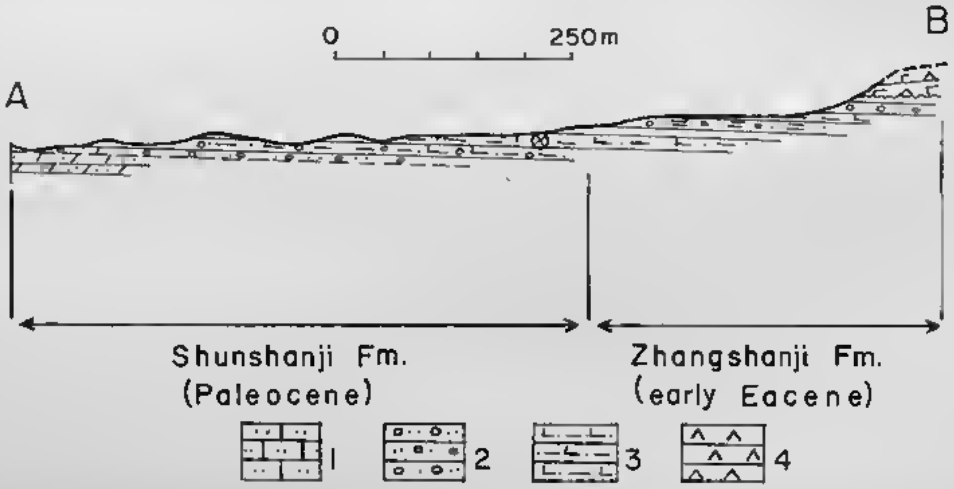


FIG. 30. — Cross section through the Wangjiagang area near Zhijiagou, Laian District, Anhui, showing in particular the deposits of the Zhangshanji Fm.; **1**. marl; **2**. gravelly sandstone; **3**. marly sandy mudstone; **4**. basalt. The fossil locality was not numbered. Modified from Zhai *et al.*, 1976.

Source : MNHN, Paris

Lat. 32° 45′ N
Long. 110° 40′-111° 20′ E
(Liguanqiao Town: 32° 46′ N; 111° 27′ E)

Fig. 2, n° 13

CHINA
HENAN PROVINCE
(Honan)
Xichuan Basin

Yuhuangding Fm. **early Eocene**

Two Chinese geologists (Li ji and Zhu sun) first discovered fossil mammals at Fanzhuang in the Xichuan [5] Basin in 1929. These were described by Teilhard de Chardin (1930). In 1959 regional geologists divided the younger deposits into three formations: the lower one, the Yuhuangding [6] Formation, the middle one, the Dacangfang [7] Formation, and the upper one, the Hetaoyuan [8] Formation. They regarded the two lower ones as late Cretaceous and the top formation as early Tertiary. In 1960, Li C.-k. and Tong, from the IVPP, discovered more fossils in the Yuhuangding Formation and showed that all three formations should be considered as Eocene in age. In 1973, a group of IVPP members (who have published under the initials of GAO, a name which stands for the Laboratory of Paleomammalogy of the IVPP) discovered

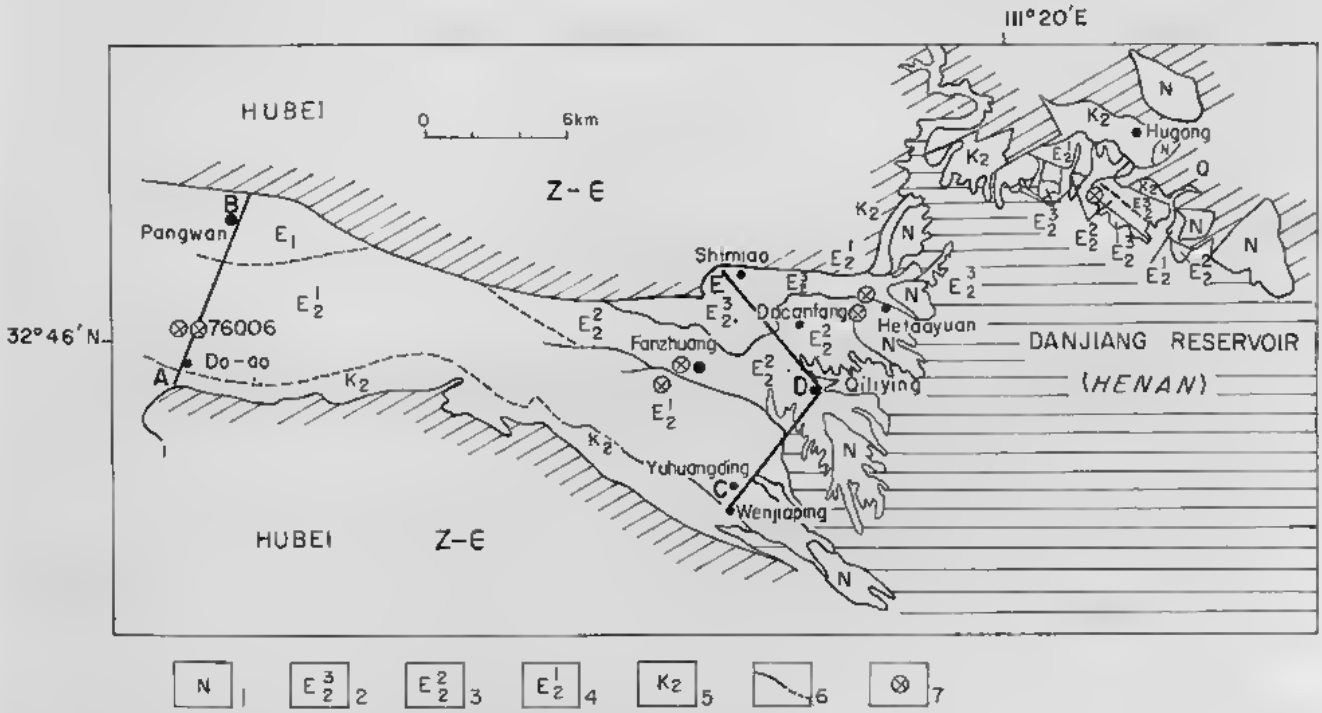


FIG. 31. — Paleogene fossil mammal localities of the Xichuan (or Liguanqiao) Basin, Hubei and Henan Provinces. 1. Neogene; 2. Hetaoyuan Fm.; 3. Dacangfang Fm.; 4 Yuhuangding Fm.; 5. Hugang Fm.; 6. stratigraphical boundary; 7. fossil mammal locality. Modified from Xu *et al.*, 1979.

5 Xichuan Basin (= Sichuan) = Xi (place name) River.
6 Yuhuangding = the hilltop temple of the god Yu.
7 Dacangfang = big store house.
8 Hetaoyuan = walnut tree orchard.

Source : MNHN, Paris

still more mammalian material and gave preliminary faunal lists for all three formations (GAO, 1976, V.P. 1).

The Xichuan Basin, on the southern slope of the Qinling Mountains (about 150 km south of the Lushi Basin), is mostly situated in Hubei Province, although it extends into Henan and is traditionally regarded as a basin of that province. It has also been called the Liguanqiao [9] Basin by a mixed team from the IVPP and the Geological Bureau of Henan, who published a summary of the stratigraphy and the faunas (Xu *et al.*, 1979).

The lowest formation, the Yuhuangding Formation, mainly consists of pink and gray thick, dense marl; a few beds of red and green clays are intercalated and there is gravel at the base. The thickness of the formation varies from 360 to 960 m.

A red sandstone, the Hugang [10] Formation,

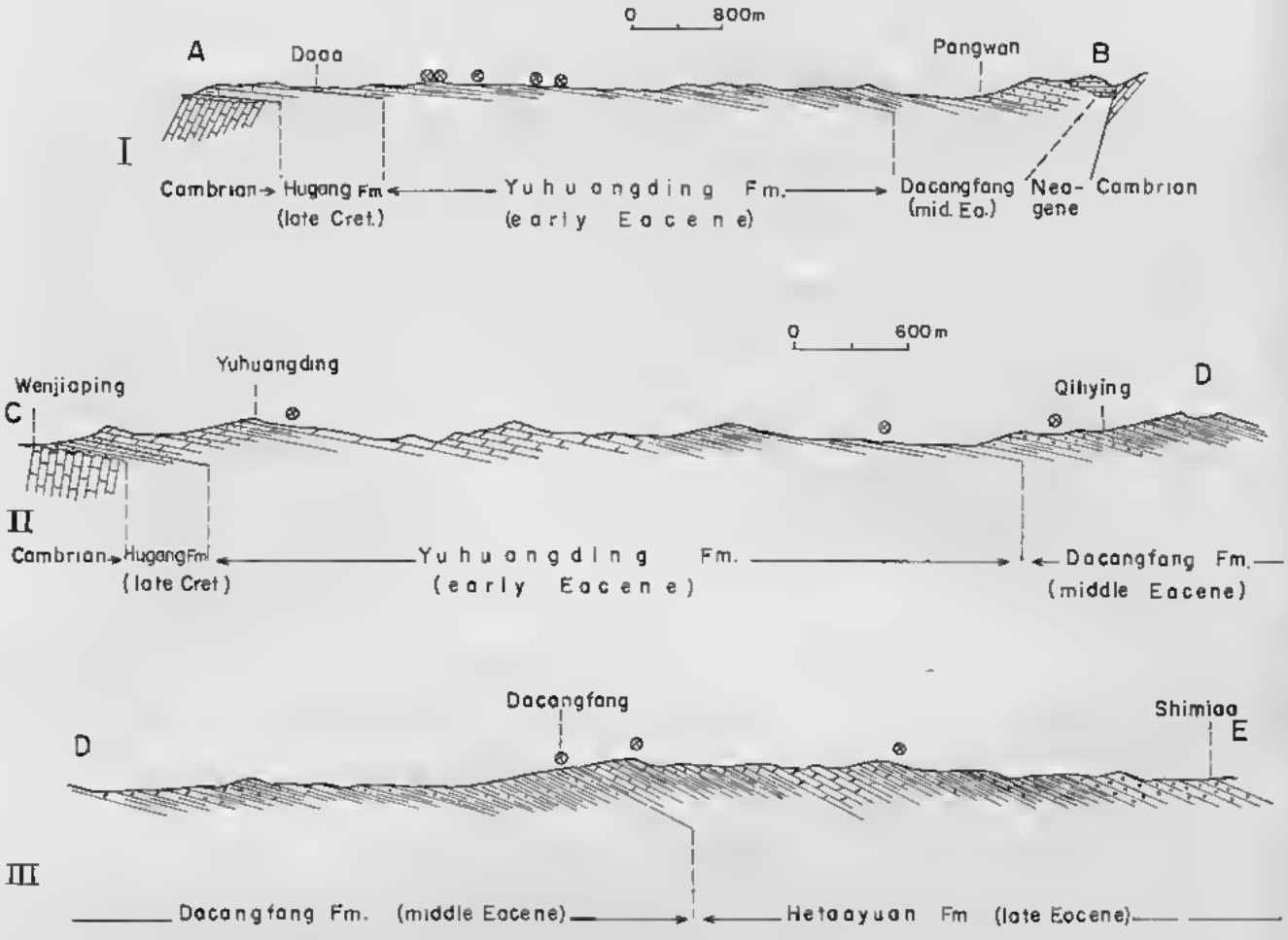


FIG. 32. — I, Section taken between Daao and Pangwan, Xichuan Basin, hubei. II and III, Cross section taken between Yuhuangding (Hubei) and Shimiao (Henan). Dashzeveg Xu *et al.*, 1979.

underlying the Yuhuangding Formation contains many pieces of dinosaur eggs; it is probably late Cretaceous in age.

Elements of the Yuhuangding Formation indicate an early Eocene age; *Rhombomylus*, for example, is found in only two localities in China, the Laian District and the Turpan Basin; the latter also contains *Hyopsodus*, *Heptodon* and *Coryphodon*. *Heptodon*, or a very similar form, is found also in the Yuhuangding Formation.

9 Liguanqiao (= Lihuanchiao) = officer Li (family name) bridge.
10 Hugang = Hu (family name) low, broad hill.

Source : MNHN, Paris

Fauna of the Yuhuangding Fm.

PANTODONTA
CORYPHODONTIDAE
— *Asiocoryphodon conicus* Xu, Y., 1976, V.P. (3)
— *Asiocoryphodon lophodontus* Xu, Y., 1976, V.P. (3)
— « *Coryphodon* » *flerowi* (Chow, 1957b, V.P. (4)) Lucas, 1982
(= *Manteodon flerowi* (Chow, 1957b) Xu, Y., 1976, V.P. (3))
(= *Manteodon* cf. *meizixiensis* Yan (*nomen nudum*?, was cited from here in error by Xu *et al.*, 1979)

DINOCERATA Indet.; cited by Schoch & Lucas, 1985
(= *Gobiatherium*? sp.; by Chow & Tung, 1962, V.P. (4))

RODENTIA
CTENODACTYLIDAE [11]
— *Advenimus hupeiensis* Dawson *et al.*, 1984

MIXODONTIA
EURYMYLIDAE
— *Rhombomylus* sp.; cited by Xu *et al.*, 1979

PERISSODACTYLA
HELALETIDAE
— cf. *Heptodon* sp.; cited by Xu *et al.*, 1979

Lat. 26° 53′ N approx.
Long. 112° 30′ E approx.

Fig. 2, n° 19

CHINA
HUNAN PROVINCE
Hengyang Basin

Limuping Fm. **early Eocene**
Locality: Lingcha

In 1938 Prof. C. C. Young discovered a fragment of a perissodactyl of great interest, as it was the first Eocene mammal found in south China and indicated a close relationship to similar forms in Europe. At the time the specimen was described it was thought to be of middle Eocene age. IVPP members in 1974 and 1976 made further collections at Lingcha and Limuping, Hengdong [12] County, Hengyang [13] Basin in central Hunan, including specimens from the same locality worked by Prof. Young and which constitutes the main area. Young called the locality Tsenpiling [14]; in the article by Li *et al.*, (1979), the name of Lingcha [15] is used but both refer to the same region. The locality lies about 15 km southwest of Hengdong City.

The fossils were found in the Limuping [16] Formation for which two sections are given. The " lower " section (Fig. 34, I; 4 levels) correlates with the lower part of the " higher " (Fig. 34, II; 8 levels) section; they therefore overlap in age, but exactly to what extent is not known.

The sediments of the " upper " section are quite variable. Level 1 is a brownish red, sandy

11 Hartenberger (pers. com., 1985) considers the Yuomyidae and Cocomyidae (families proposed by Dawson *et al.*, 1984) to merit no more than subfamily status within the Ctenodactylidae. This explains the absence of these " families " from our faunal lists.
12 Hengdong (= Hengtung) = County name, situated to the east of Hengyang City.
13 Hengyang = south of Heng (place name) Mountain; refers to Hengyang City.
14 Tsenpiling (= Chiangpiliang) = Tsenpi (place name) Hill.
15 Lingcha = hill with many oil-tea camellia bushes.
16 Limuping (= Limoping) = chestnut tree orchard.

Source : MNHN, Paris

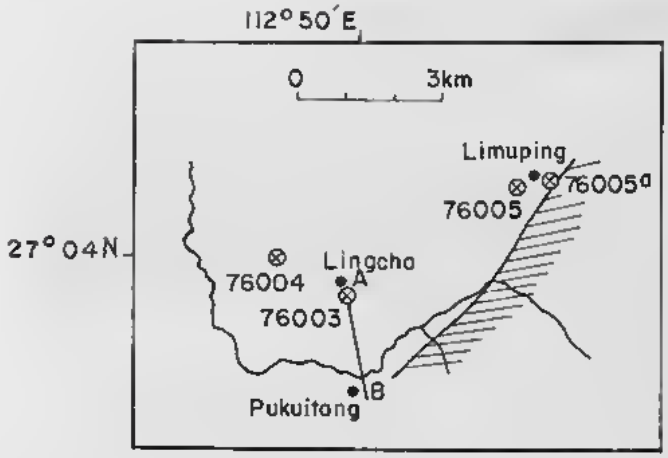


FIG. 33. — Sketch map of the fossil localities in the Hengyang Basin, Hunan. Modified from Li *et al.*, 1979.

mudstone disconformably overlying early Devonian sandstone; thickness, 142 m. 2. Yellowish green medium-coarse sandstone, interbedded with mudstone; 10 m. 3. Interbedded purplish red sandstone and mudstone, containing yellowish green thick-layered coarse sandstone; 88 m. 4. Purplish red mudstone, with thin, discontinuous calcareous silty mudstone and dark red siltstone; 22 m. 5. Gray calcareous, thin, fine grained sandstone, interbedded with purplish red mudstone; 37 m. 6. Purplish red mudstone, with grayish green thin-bedded marl; the mudstone contains abundant concretions. Yellowish green clay appears at the top; 53 m. 7. Purplish red mudstone, with abundant concretions. Fine sandstone appears at the top; 24 m. Locality 76003 is in this level, from which *Propachynolophus hengyangensis*, *Cocomys lingchaensis*, *Asiocoryphodon*? sp., *Matutinia nitidulus* and an undescribed insectivore were recovered in 1976. Although locality 76004 is not in this section it corresponds to this level; it has yielded *Hunanictis inexpectatus* and *Matutinia nitidulus*. 8. Yellowish green and gray mudstone and shale. It was here that the first discovery of *Propachynolophus* (= "*Propalaeotherium*") *hengyangensis* was made by Young in 1938. The whole section has a thickness of about 400 m and has furnished fossil mammals only in the two top levels.

The "lower" part begins with (level 1) dark red fine sandstone, containing breccia, disconformably overlying Devonian sandstone; visible thickness, 8 m. Fragments of unidentified mammals were found in this level. 2. Yellowish green silty sandstone and mudstone, with hard sandy marl at the top; 18 m. 3. Interbedded purplish red mudstone and pink sandy mudstone; 79 m. Locality 76005a is found at its base, where a lower jaw fragment of *Archaeolambda* sp. was found in 1974. 4. Purplish mudstone interbedded with gray calcareous silty sandstone; visible thickness, 31 m. Locality 76005 is not exactly on the section line, but it corresponds to the middle

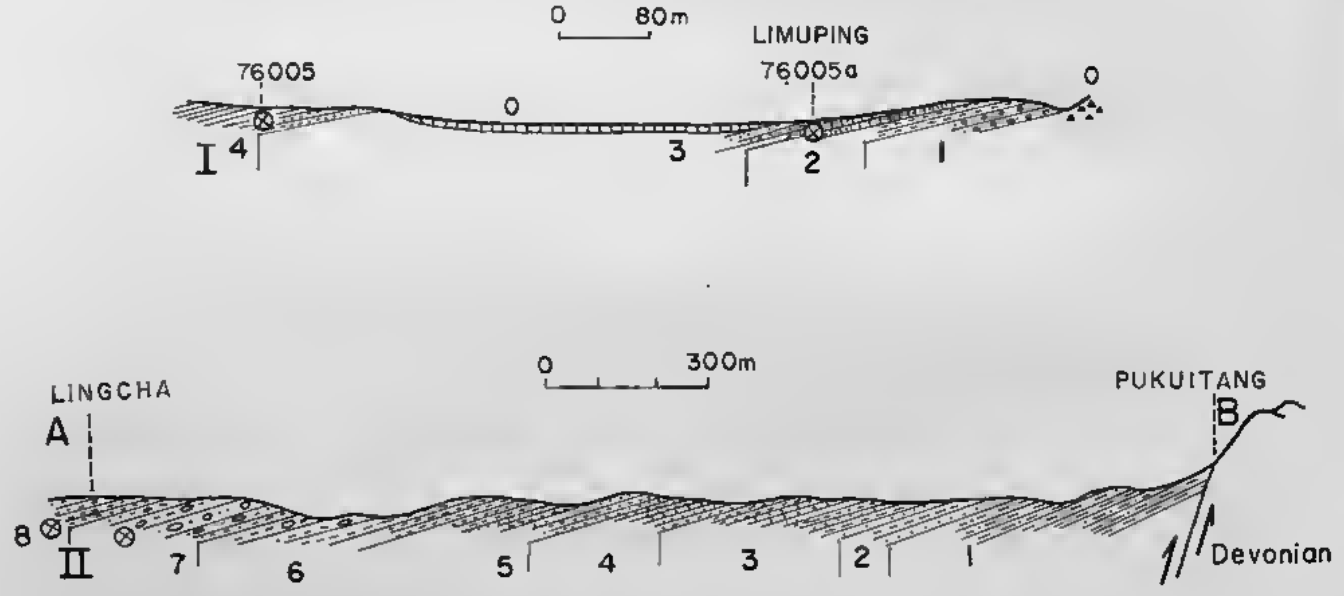


FIG. 34. — I. Cross section between localities 76005 and 76005a in the Hengyang Basin. II, Cross section between Lingcha and Pukuitang, Hengyang Basin, Hunan. The Paleogene sediments in both sections represent the early Eocene Limuping Formation; see text for explanation. Modified from Li *et al.*, 1979.

Source : MNHN, Paris

part of this level. An archaeolambdid lower jaw was found here. The total thickness of the " lower " section is about 130 m.

The " lower " section has furnished only a single mammal genus, which is comparable to a similar form from the Naran-Bulak fauna and probably late Paleocene. The " upper " section, which has provided most of the fossil material, is more certainly of early Eocene age; on the European scale it probably is not later than Cuisian. The Limuping Formation corresponds approximately to the Xinyu Formation of Jiangxi, the Yuhuangding Formation of Henan and the Zhangshanji Formation of Anhui. Its correlation with the Wutu Formation (Shandong) is less certain.

The presence of *Propachynolophus* in this fauna and in that of the early Eocene of Europe permits some speculation on the nature of the continental relationships that existed between eastern Asia and Europe at that time.

Fauna of the Limuping Fm.

INSECTIVORA Indet. cited by Li *et al.*, 1979, V.P. 1

PANTODONTA

PANTOLAMBDODONTIDAE — *Archaeolambda* sp.; cited by Li *et al.*, 1979, V.P. (1) [17]

CORYPHODONTIDAE — *Asiocoryphodon*? sp.; cited by Li *et al.*, 1979. V.P. (1)

RODENTIA

CTENODACTYLIDAE [18] — *Cocomys lingchaensis* (Li *et al.*, 1979) Dawson *et al.*, 1984
(= *Microparamys lingchaensis* Li *et al.*, 1979, V.P. (1))

MIXODONTIA

EURYMYLIDAE — *Matutinia nitidulus* Li *et al.*, 1979, V.P. (1)

PERISSODACTYLA

EQUIDAE — *Propachynolophus hengyangensis* (Young, 1944) Li *et al.*, 1979, V.P. (1)
(= *Propalaeotherium hengyangensis* Young, 1944, Am. Mus. Novit. n° 1268)
(= *Adapidium?* sp., *in* Young, Bien & Lee, 1938)

ORDER Indet.

DIDYMOCONIDAE — *Hunanictis inexpectatus* Li *et al.*, 1979, V.P. (1)
— *Hsiangolestes youngi* Zheng & Huang, 1984, V.P. (3)

17 This form comes from a lower level than the other taxa.
18 See footnote 11, p. 77.

Source : MNHN, Paris

Lat. 27° 25′ N
Long. 114° 55′ E
(Xinyu City)

Fig. 2, n° 18

CHINA
JIANGXI PROVINCE
(Kiangsi)
Yuanshui Basin

Xinyu Fm. **early Eocene**
Locality: Ningjiashan

The Yuanshui [19] Basin, situated in central Jiangxi, first yielded fossil vertebrate remains to the archaeologist Rao in 1954 at the locality of Ningjiashan [20]. This faunule was described by Chow (1959) and in 1961 an IVPP team collected more fossils from the red beds of the district, followed by another party in 1972.

The fossiliferous sediments are part of the Xinyu [21] Formation, which reposes disconformably on the late Cretaceous Qingfengqiao [22]

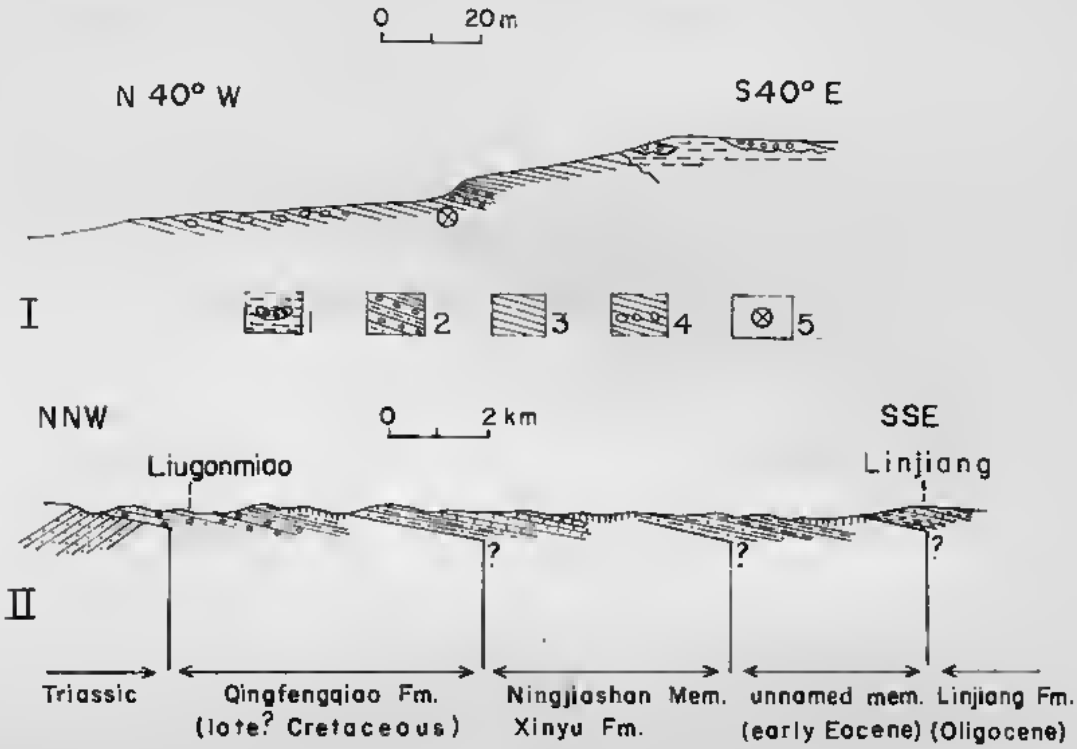


FIG. 35. — I. Cross section taken at Ningjiashan, Yuanshui Basin, Jiangxi, showing the fossil mammal locality. 1. Quaternary gravelly clay; 2. sand and gravel; 3. sandy mudstone; 4. sandy mudstone with concretions (2, 3 and 4 represent the Ningjiashan Member of the Xinyu Fm.). Modified from Chang & Tung, 1963. II. Cross section taken between Liugonmiao and Linjiang, Yuanshui Basin, Jiangxi. The early Eocene unnamed member is referred to the Xinyu Formation. Modified from Zheng *et al.*, 1975.

19 Yuanshui = Yuan (family name) River.
20 Ninjiashan = Ning (family name) Hill.
21 Xinyu = new Yu (place name).
22 Qingfengqiao = harvest bridge (this was the " lower " member of the Xinyu Group, according to Chang & Tung, 1963, V.P. (2)).

Source : MNHN, Paris

Formation, and which is overlain by the Oligocene(?) Linjiang [23] Formation. The Xinyu Formation (sometimes called a group) is divided into two members, the lower one of which is the fossiliferous Ningjiashan [24] Member; the upper member is unnamed and has yielded no fossils. The Ningjiashan Member is principally comprised of purplish red, grayish purplish sandstone and is sometimes conglomeratic. This sandstone is also green with grayish green, grayish white fine sandstone containing calcite concretions. Its thickness is from 600 to 900 m.

A tentative age of early Eocene is applied to these sediments. The material referred to *Prodinoceras* (" *Phenaceras* ") and to *Heptodon* is very fragmentary and identification is uncertain. The " *Coryphodon* " form represented here is primitive, as is the miacid. On the whole, the aspect of the fauna is one of the early Eocene.

Fauna of the Xinyu Fm. (Ningjiashan Member)

PANTODONTA

CORYPHODONTIDAE

— *" Coryphodon " ninchiashanensis* (Chow & Tung, 1965) Lucas, 1982
(= *Coryphodon ninchiashanensis* Chow & Tong, 1965, V.P. (1))
(= *Asiocoryphodon ninchiashanensis* Chow & Tung, 1965, *in* Xu, 1976)

— *Coryphodon* sp.; cited by Chow, 1959, V.P. (2)

DINOCERATA

UINTATHERIIDAE

— *Prodinoceras sinyuensis* (Chow & Tung, 1962) Schoch & Lucas, 1985
(= *Phenaceras sinyuensis* (Chow & Tung, 1962) Tong & Lucas, 1982)
(= *Phenaceras? sinyuensis* (Chow & Tung, 1962) Tong, 1979b)
(= *Probathyopsis? sinyuensis* Chow & Tung, 1962)

CARNIVORA

MIACIDAE

— *Miacis tenuis* (Zheng *et al.*, 1975) Gingerich, 1983
(= *Xinyuictis tenuis* Zheng *et al.*, 1975, V.P. (2))

PERISSODACTYLA

HELALETIDAE

— *Heptodon*? sp.; cited by Zheng *et al.*, 1975, V.P. (2)

23 Linjiang = river side.
24 Ningjiashan (= Linjiashan) = Ning (family name) Hill.

Source : MNHN, Paris

Lat. 36° 42′ N
Long. 118° 49′ E
(Changle City)
Lat. 36° 30′ N
Long. 118° 32′ E
(Linqu City)

Fig. 2, n° 6

CHINA
SHANDONG PROVINCE
(Shantung)
Changle and Linqu Districts

Wutu and Niushan Fms. **early Eocene**

In 1962, IVPP members discovered fossil mammals in the Wutu [25] Basin (Changle District) of central Shandong. A second trip was made in 1964; in the Wutu Formation additional material of *Homogalax* was found, plus some unidentifiable pantodont remains. The Wutu Formation is composed of dark colored oil shales, coal, purple red or green mudstones and conglomerates; the fossils came from near the coal beds of the middle of the Wutu Formation. Outcrops of Eocene beds in this area are very limited and fossils are extremely rare.

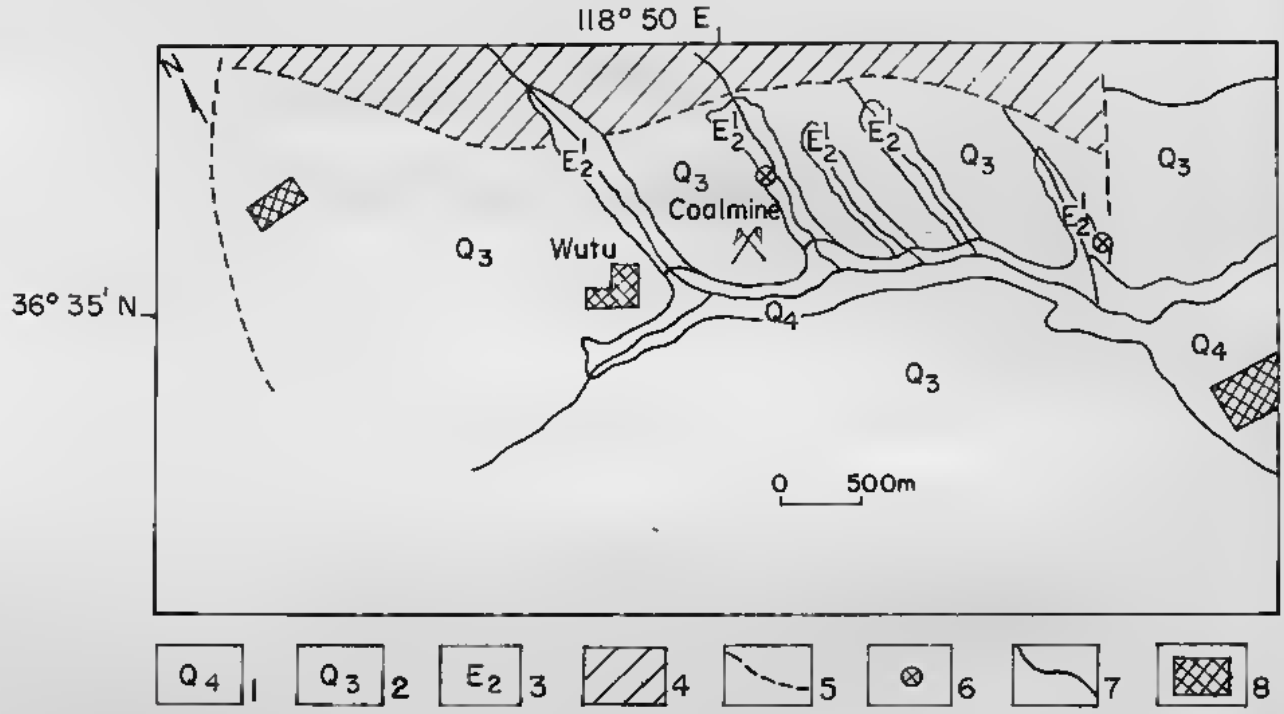


FIG. 36. — Outcrop map of the Wulu Fm. at Wutu, Shandong. 1. Recent deposits; 2. late Quaternary loess; 3. early Eocene Wulu Fm.; 4. Paleozoic limestone; 5. fault; 6. fossil mammal locality; 7. stratigraphic boundary; 8. town or village. The Wutu Fm. crops out in the bottom of the valleys and is overlain by thick Quaternary loess. There is a fault between the Wulu Fm. and the pre-Tertiary granite. It is not possible to take a section through the Wutu Fm. From a map provided by Wang J.-w.

25 Wutu = five pictures.

Source : MNHN, Paris

During the second trip, material of *Heptodon* was found at Niushan [26] in the neighboring district of Linqu. This locality is 8 km south of Linqu City and in the dominantly gray-green marly beds of the Niushan Formation (or member?). The latter also includes black oil shales and brownish red clay, mudstone and sandstone; it is stratigraphically slightly higher than the nearby fossiliferous beds that produced *Homogalax*.

These fossils were extremely important in being the first to establish the presence of early Eocene deposits in north China; both genera occur in North American beds of this age.

Fauna of the Niushan Fm.

PERISSODACTYLA
HELALETIDAE — *Heptodon niushanensis* Chow & Li, 1965, V.P. (1)

Fauna of the Wutu Fm. (middle part)

PANTODONTA Indet., cited by Chow & Li, 1965, V.P. (1)
PERISSODACTYLA
ISECTOLOPHIDAE — *Homogalax wutuensis* Chow & Li, 1965, V.P. (1)

Lat. 42° 30′ - 43° 30′ N
Long. 88° 00′ - 92° 00′ E

Fig. 2, n° 1

CHINA
XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)
Turpan Basin

Dabu and Shisanjianfang Fms. **early Eocene**

The Turpan Basin, in east central Xinjiang, is elongate in a generally east-west direction and bounded by Paleozoic rocks to the north, west and south; eastward it grades into younger deposits (see map, Fig. 20, under Taizicun Fm., p. 55). A long fault cuts longitudinally through the basin, which by uplift of the northern block has exposed Jurassic, Cretaceous, Paleogene and Neogene rocks. In the eastern part of the basin strata (Cenozoic and late Cretaceous) are normally nearly horizontal. This central uplift in the eastern region has been termed (unofficially) by the members of the IVPP, the " Middle " Mountains [27]. Two early Eocene localities were discovered by an IVPP crew in 1966: one south of the " Middle " Mountains (loc. n° 66015) in the Dabu [28] Formation and the other (loc. n° 66019) in the Shisanjianfang [29] Formation north of the " Middle " Mountains. The surface beds on each side of the mountains in this eastern area are Oligocene and nearly flat-lying; older formations are only found exposed in gullies. No further research for fossil mammals has been made here since 1966.

26 Niushan = ox hill.
27 " middle " mountains = Bogda Shan = Bogeda Shan.
28 Dabu = big step.
29 Shisanjianfang = 13 rooms.

Source : MNHN, Paris

The Dabu Formation overlies the late Cretaceous Subashi [30] Formation, which is characterized by dinosaur eggs, and there is apparently continuous sedimentation between them, although no fossils in this interval have as yet been found. The Dabu Formation is predominantly made up of white or gray-white sand or sandstone. It has been divided into 6 levels, which constitute a thickness of about 22 m.

The Shisanjianfang Formation is composed of

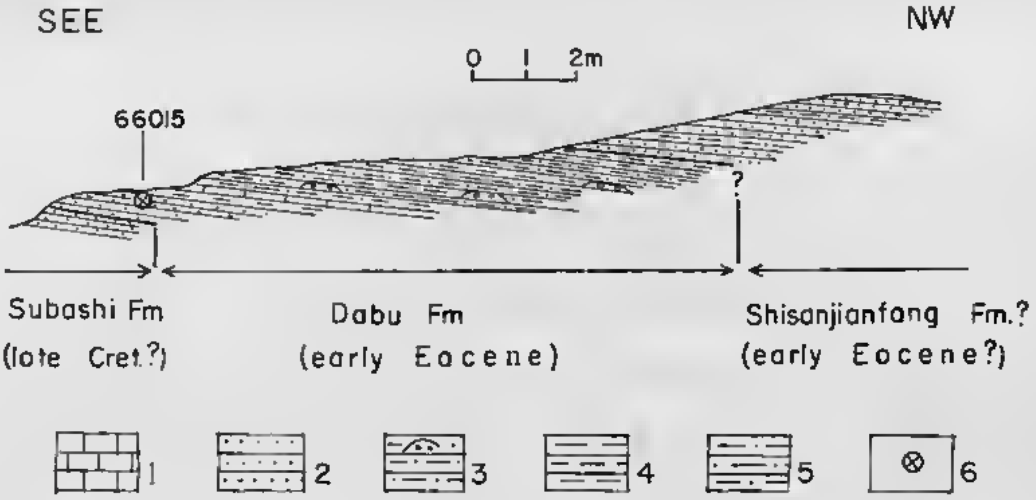


FIG. 37. — Cross section taken at loc. 66015, about 38 km south of Dabu station, Xinjiang. **1.** freshwater limestone or marl; **2.** sandstone; **3.** sandy mudstone with gravel lens; **4.** mudstone; **5.** sandy mudstone; **6.** fossil mammal locality. Modified from Zhai *et al.*, 1978.

272 m of reddish sandy clay; the fossil level (with locality 66019) is between 18 and 30 m from the top.

Correlation of the Dabu Formation is aided by the species of *Coryphodon* (which is the most primitive known in China) and by the uintathere specimen, which is more advanced than the Gashato *Prodinoceras*.

Conservatively, the Shisanjianfang Formation could be considered as early Eocene or slightly younger, but the *Heptodon* species does seem similar to late early Eocene forms from North America. *Hyopsodus* occurs throughout the Eocene, but the material described from here is relatively primitive, also supporting an early Eocene age.

It is not sure that *Anatolostylops dubius* was found in the Shisanjiangfang Formation. Its field number was lost and the possibility exists that it came from the overlying lower Taoshuyuanzi Formation (early Oligocene).

With respect to the relationships existing between the Dabu and the Shisanjianfang Formations, it is possible that the former might be of earlier age, but so far there is no firm stratigraphic evidence.

Fauna of the Dabu Fm.

PANTODONTA

CORYPHODONTIDAE — *Coryphodon dabuensis* Zhai 1978a

DINOCERATA

UINTATHERIIDAE — *Prodinoceras xinjiangensis* (Zhai, 1978a) Schoch & Lucas, 1985 (= *Pyrodon xinjiangensis* Zhai, 1978a)

30 Subashi: translation not known; not Chinese.

Source : MNHN, Paris

Fauna of the Shisanjianfang Fm.

PANTODONTA	
CORYPHODONTIDAE	— *Coryphodon* sp.; cited by Zhai, 1978b
MIXODONTIA	
EURYMYLIDAE	— *Rhombomylus turpanensis* Zhai, 1978b
CONDYLARTHRA	
HYOPSODONTIDAE	— *Hyopsodus* sp.; cited by Zhai, 1978b
PERISSODACTYLA	
HELALETIDAE	— *Heptodon tienshanensis* Zhai, 1978b
NOTOUNGULATA	
ARCTOSTYLOPIDAE	— *Anatolostylops dubius* Zhai, 1978b

Lat. 31° N, approx.
Long. 77° E, approx.

INDIA

HIMACHAL PRADESH

(Simla Himalayas)

Subathu Formation **early Eocene**

Localities: Subathu and Dharampur

Small collections of fossil mammals have been recovered from the marine beds of the Subathu Formation near the town of Subathu. One locality is situated on a bridle path leading from the Kuthar Nala (stream bed) to the steep escarpment of the southern slope of the hill comprising the Subathu Formation type section. Cetacean material and a specimen related to *Pilgrimella* were found here.

The Dharampur localities comprise roadside exposures along the main Kalka-Simla highway and are in beds representing lateral extensions of the type Subathu; fossil vertebrates are found in several levels.

Another site in the marine beds near the town of Subathu has yielded " *Bunodentus* " indicating that this taxon, along with the Anthracobunidae, had a temporal range that extended from the early Eocene to the Middle Eocene. A more detailed discussion of the Subathu Formation and its fossil content is to be found in the middle Eocene chapter. The Subathu Formation in its type area is dominantly calcareous and is dated as Ypresian (early Eocene) by foraminiferal biostratigraphy. The fossiliferous deposits typify very shallow water and high energy strand-line environments.

Fauna of the Subathu Formation

ARTIODACTYLA	
RAOELLIDAE	— *Khirtharia dayi* Pilgrim, 1940 (= *Bunodentus inflatus* Ranga Rao, 1972; cited by Ranga Rao and Misra, 1981)

Source : MNHN, Paris

PROBOSCIDEA

ANTHRACOBUNIDAE — cf. *Pilgrimella* sp.; *in* Gingerich & Russell, 1981
(= *Ishatherium subathuensis* Sahni & Kumar, 1980)

CETACEA Indet.; cited by Sahni & Kumar, 1980

SIRENIA Indet.; cited by Sahni & Kumar, 1980

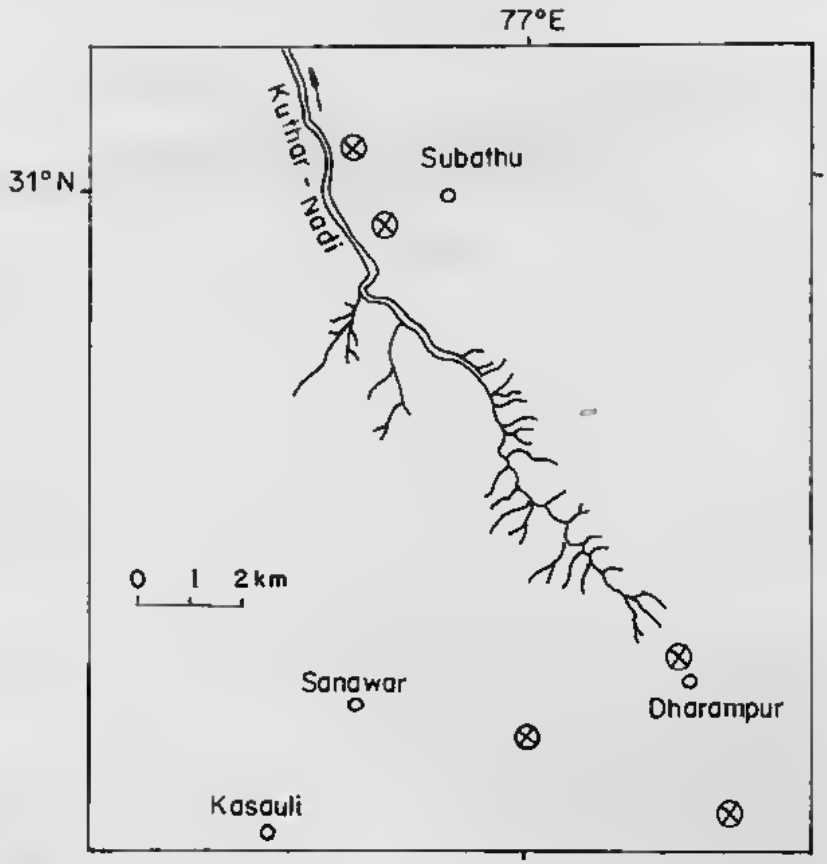


FIG. 38. — Sketch map showing the early Eocene vertebrate localities in the region of Subathu and Dharampur. The most northern of these localities has furnished remains of fossil mammalian teeth. Modified from Sahni & Kumar, 1980.

Lat. 44° 10′ N, approx.
Long. 103° 45′ E approx.

Fig. 1, n° 26

MONGOLIA

OMONO GOBI PROVINCE

Ulan-Nur Basin

unnamed svita **early Eocene**

Locality: Gashato

The biostratigraphy of the Gashato locality has been treated in detail in the Paleocene chapter.

We consider the presence of *Gomphos elkema*, high in the section (bed 13, Fig. 22) to indicate a correlation with the more complete early Eocene

Source : MNHN, Paris

fauna from the Bumban Member of the Naran-Bulak Svita in the Nemegt Basin. The latter assemblage contains a dominance of forms typifying the Wasatchian and Ypresian faunas of North America and Europe. *Gomphos*, itself, may range into the middle Eocene.

Fauna of the unnamed svita at Gashato.

MIXODONTIA

MIMOTONIDAE — *Gomphos elkema* Shevyreva, 1975 (*in* Shevyreva, Chkhikvadze & Zhegallo, 1975)

Lat. 43° 28′ N, approx.
Long. 100° 23′ E approx.

Fig. 1, n° 12

MONGOLIA
OMONO GOBI PROVINCE
Nemegt Depression
Naran-Bulak Svita

Bumban Member **early Eocene**
Locality: Tsagan-Khushu

For a more complete account of the Naran-Bulak Svita, the reader is referred to the Paleocene chapter where the lower part (the Zhigden and Naran Members) is discussed. The upper part is considered here.

The fauna at Tsagan-Khushu was discovered by Dashzeveg in 1964 during the Polish-Mongolian Paleontological Expedition of that year; further collections were made in 1965. Additional excavations (with screenwashing) were made by Dashzeveg from 1973 to 1979, in conjunction with Soviet-Mongolian Paleontological Expeditions. The sediments of early Tertiary age, situated about 8 km west of Naran-Bulak, are exposed in the southeastern part of the area referred to as Tsagan-Khushu, a region that first attracted attention because of the dinosaur skeletal material it yielded. According to Devyatkin (1981), who studied the geology of the area in 1969-1973, the most complete section of the Naran-Bulak Svita, however, is found in a ravine west of Tsagan-Khushu.

The Bumban [31] Member, the first of the Eocene section, is composed mainly of red argillaceous sandstones which lie in concordance on the Naran beds; its thickness is 20 m. The fauna that

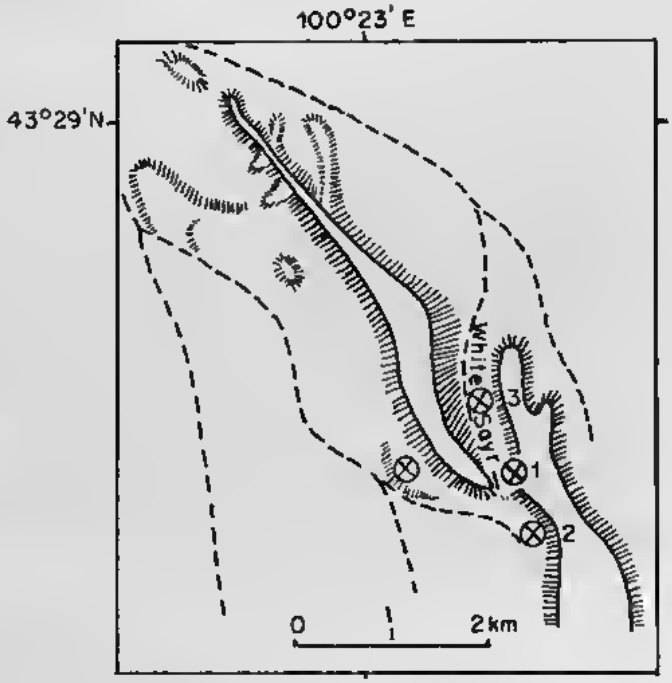


FIG. 39. — Sketch map showing the situation of the Tsagan-Khushu locality, Nemegt Basin, Mongolia. Sites 1 and 2 represent the quarries discovered by Dashzeveg in the Bumban Member; the quarry 3 fauna, from the Zhigden Member, is not yet described. The locality to the west of the Eocene quarries is in a Paleocene level. Modified from Gradzinski *et al.*, 1968/1969.

31 Bumban (= Bumbin = Bumbin Nuru) = suction-cup shape mountain.

Source : MNHN, Paris

has been collected at Tsagan-Khushu [32] comes from lenses of light yellow and brownish sandstone and gravels at the base of the member. *Altanius orlovi*, *Gomphos elkema*, *Hyopsodus orientalis*, *Hyracotherium gabuniai*, *Homogalax namadicus*, ctenodactylid rodents, artiodactyls, several sorts of insectivores, as well as lizards, salamanders and birds are now known. Higher in the section, in the southern part of Tsagan-Khushu, have been found *Gomphos elkema*, *Arctostylops* n. sp. and rodents.

A top and fourth member has been tentatively referred to the Naran-Bulak Svita by Dashzeveg, and called Aguyt. It is represented by 10 m of gray argillaceous sandstone with intercalations of calcareous concretions. This member is missing at Tsagan-Khushu, but appears in the region of Ulan-Bulak. The only mammalian fossil so far recovered from it is referred to as *Gomphos* cf. *elkema*.

The fauna of the Bumban Member, particularly well represented at Tsagan-Khushu, is typically that of the Holarctic early Eocene; an association of *Homogalax*, *Hyopsodus*, *Hyracotherium*, and the presence of artiodactyls, rodents and omomyid primates, affords a direct correlation with the well known and well dated faunas of Europe and North America (see Rose, 1981, Russell *et al.*, 1982a).

Fauna of the Naran-Bulak Svita
(Bumban Member)

INSECTIVORA	
NYCTITHERIIDAE	— *Bumbanius rarus* Russell & Dashzeveg, 1986
	— *Oedolius perexiguus* Russell & Dashzeveg, 1986
	— Insectivora indet,; cited by Russell & Dashzeveg, 1986
PROTEUTHERIA	
PALAEORYCTIDAE	— *Naranius infrequens* Russell & Dashzeveg, 1986
	— *Tsaganius ambiguus* Russell & Dashzeveg, 1986
PANTOLESTIDAE	Indet.; cited by Russell & Dashzeveg, 1986
PRIMATES	
OMOMYIDAE	— *Altanius orlovi* Dashzeveg & McKenna, 1977
MIXODONTIA	
MIMOTONIDAE	— *Gomphos elkema* Shevyreva, 1975 (*in* Shevyreva, Chkhikvadze & Zhegallo, 1975)
EURYMYLIDAE	— *Rhombomylus* cf. *turpanensis* Zhai, 1978b; cited by Dashzeveg, pers. com., 1982
	— Eurymylidae indet.; cited by Dashzeveg, pers. com., 1984
RODENTIA	
CTENODACTYLIDAE [33]	— *Esesempomys centralasiae* Shevyreva, 1983, *nomen nudum*
TAMQUAMMYIDAE (*nomen nudum*)	— *Adolosomys ameriotos* Shevyreva, 1983, *nomen nudum*
	— *Tsaganchuschumys onos* Shevyreva, 1983, *nomen nudum*
	— *Tsaganchuschumys depiphatos*, Shevyreva, 1983, *nomen nudum*
	— *Bumbanomys edestos* Shevyreva, 1983, *nomen nudum*
IVANANTONIIDAE (*nomen nudum*)	— *Ivanantonia efremovi* Shevyreva, 1983, *nomen nudum*

32 Dashzeveg & McKenna (1977) note the absence of the Bumban Member at the Naran-Bulak locality.

33 Referred to the Chapattimyidae by Shevyreva (1983). The Chapattimyidae are regarded as primitive forms in the family Ctenodactylidae by Hartenberger (1982), meriting no more than subfamilial status.

In an article that appeared while this work was in press, Flynn *et al.*, 1986, redefined the Chapattimyidae and contradicted Hartenberger's opinion of its status as a subfamily only. They also consider the Cocomyidae and Yuomyidae as valid families.

Source : MNHN, Paris

CREODONTA
HYAENODONTIDAE Indet.; cited by Dashzeveg, pers. com. 1983
CONDYLARTHRA
HYOPSODONTIDAE — *Hyopsodus orientalis* Dashzeveg, 1977
ARTIODACTYLA Indet.; cited by Dashzeveg, 1982a
PERISSODACTYLA
EQUIDAE — *Hyracotherium gabuniai* Dashzeveg, 1979b
ISECTOLOPHIDAE — *Homogalax namadicus* Dashzeveg, 1979c [34]
NOTOUNGULATA
ARCTOSTYLOPIDAE — *Arctostylops* n. sp.; cited by Dashzeveg, 1982a
ORDER Indet.
FAMILY indet. — cf. *Hyracolestes* sp.; cited by Russell & Dashzeveg, 1986

Lat. 30° 15′ N, approx.
Long. 71° 8′ 45″ E, approx.

PAKISTAN

NORTH WEST FRONTIER PROVINCE

Kuldana Formation **early Eocene?**

Locality: Barbora

In 1979 and 1980 teams from Howard University and the University of Michigan, in collaboration with the Geological Survey of Pakistan, discovered two rich mammal localities in grit bands of the lower Kuldana Formation, .8 to 1.5 km south of the village of Barbora [35]. Rather surprisingly, the fauna collected consists principally of numerous remains of a small artiodactyl, *Diacodexis*; second in abundance, but far more rare, are the bones, teeth and jaws of a primitive perissodactyl, perhaps referable to *Homogalax*. At Barbora II a large incisor and a large perissodactyl lower molar fragment indicate the presence of one, or two, other taxa; except for a few isolated rodent teeth and a large canine, that completes the known assemblage.

The presence of the primitive dichobunid artiodactyl *Diacodexis* in the fauna, coupled with a form similar to *Homogalax*, strongly suggests an early Eocene age for it. These two genera are known in the Wasatchian of North America, *Diacodexis* from the Ypresian of Europe and *Homogalax* from the early Eocene of China and Mongolia; both are restricted to localities of early Eocene age. The problem of the age of the Kuldana Formation (whether it is diachronous or if the western localities are from lower in the formation than the eastern localities) is discussed in the middle Eocene chapter.

Fauna of the Kuldana Formation at Barbora

RODENTIA
"PARAMYIDAE" Indet.; cited by de Bruijn *et al.*, 1982; familial attribution doubted by Hartenberger, pers. com., 1983
CTENODACTYLIDAE — genus A, species I; cited by de Bruijn *et al.*, 1982
— genus A, species II; cited by de Bruijn *et al.*, 1982

34 J. J. Hooker (pers. com., 1986) regards this form as a chalicothere.
35 Barbora Banda (banda = village) (the precise area at Barbora II is called Kokushan).

Source : MNHN, Paris

CARNIVORA Indet.; seen by the authors

PERISSODACTYLA

ISECTOLOPHIDAE — cf. *Homogalax* sp.; opinion of the authors

HYRACODONTIDAE Indet.; seen by the authors

ARTIODACTYLA

DICHOBUNIDAE — *Diacodexis pakistanensis* Thewissen *et al.*, 1983

EARLY EOCENE

Composite list

(**Bar**: Barbora; **Chan**: Changle; **Ga**: Gashato; **Heng**: Hengyang; **Lai**: Laian; **Lin**: Linqu; **Sub**: Subathu; **Tsa**: Tsagan-Khushu; **Tur**: Turpan; **Yuan**: Yuanshui; **Xi**: Xichuan)

INSECTIVORA

NYCTITHERIIDAE

Tsa — *Bumbanius rarus*

Tsa — *Oedolius perexiguus*

Tsa, Heng INSECTIVORA Indet.

PROTEUTHERIA

PALAEORYCTIDAE

Tsa — *Naranius infrequens*

Tsa — *Tsaganius ambiguus*

Tsa PANTOLESTIDAE Indet.

PRIMATES

OMOMYIDAE

Tsa — *Altanius orlovi*

PANTODONTA

PANTOLAMBDODONTIDAE

Heng — *Archaeolambda* sp.

CORYPHODONTIDAE

Xi — *Asiocoryphodon conicus*

Xi — *Asiocoryphodon lophodontus*

Heng — *Asiocoryphodon*? sp.

Xi — "*Coryphodon*" *flerowi*

Yuan — "*Coryphodon*" *ninchiashanensis*

Tur — *Coryphodon dabuensis*

Tur, Yuan — *Coryphodon* sp.

DINOCERATA

UINTATHERIIDAE

Yuan — *Prodinoceras sinyuensis*

Tur — *Prodinoceras xinjiangensis*

Xi — Dinocerata indet.

RODENTIA

Bar "PARAMYIDAE" Indet.

CTENODACTYLIDAE

Xi — *Advenimus hupeiensis*

Heng — *Cocomys lingchaensis*

Bar — Ctenodactylidae indet.

MIXODONTIA

MIMOTONIDAE

Ga, Tsa — *Gomphos elkema*

Source : MNHN, Paris

EURYMYLIDAE

Lai — *Rhombomylus laianensis*
Tur — *Rhombomylus turpanensis*
Tsa — *Rhombomylus* cf. *turpanensis*
Xi — *Rhombomylus* sp.
Heng — *Matutinia nitidulus*
Tsa — Eurymylidae indet.

CARNIVORA

MIACIDAE

Yuan — *Miacis tenuis*

CREODONTA

Tsa HYAENODONTIDAE Indet.

CONDYLARTHRA

HYOPSODONTIDAE

Tsa — *Hyopsodus orientalis*
Tur — *Hyopsodus* sp.

PERISSODACTYLA

EQUIDAE

Tsa — *Hyracotherium gabuniai*
Heng — *Propachynolophus hengyangensis*

ISECTOLOPHIDAE

Tsa — *Homogalax namadicus*
Chan — *Homogalax wutuensis*
Bar — cf. *Homogalax* sp.

HELALETIDAE

Lin — *Heptodon niushanensis*
Tur — *Heptodon tienshanensis*
Xi — cf. *Heptodon* sp.
Yuan — *Heptodon*? sp.

ARTIODACTYLA

DICHOBUNIDAE

Bar — *Diacodexis pakistanensis*
Tsa — Artiodactyla indet.

RAOELLIDAE

Sub — *Khirtharia dayi*

NOTOUNGULATA

ARCTOSTYLOPIDAE

Tsa — *Arctostylops* n. sp.
Tur — *Anatolostylops dubius*

PROBOSCIDEA

ANTHRACOBUNIDAE

Sub — cf. *Pilgrimella* sp.

Sub CETACEA Indet.

Sub SIRENIA Indet.

ORDER Indet.

DIDYMOCONIDAE

Heng — *Hunanictis inexpectatus*
Heng — *Hsiangolestes youngi*

FAMILY Indet.

Tsa — cf. *Hyracolestes* sp.

Source : MNHN, Paris

Lat. 23° 35′ - 23° 50′ N
Long. 105° 35′-107° 10′ E

Fig. 2, n° 23

CHINA
GUANGXI ZHUANGZU AUTONOMOUS REGION
(Kwangsi)
Bose Basin

Dongjun Fm. **middle Eocene**

The first work done in the Bose[1] Basin (in western Guangxi) was by the Geological Survey of China, but no fossils were found. In 1957 Chow recorded and described specimens that had been collected by oil geologists in 1954. IVPP teams in 1973 and 1974 made extensive collections and divided the early Tertiary deposits into 4 parts. The NW-SE elongate Bose Basin is separated from the small Yongle[2] Basin by a range of hills, but the Dongjun Fm. (and the underlying Liuniu Fm.) is present only in the Bose Basin. The overlying Naduo Fm. and the reputedly Oligocene Gongkang Fm. are present in both; they will be discussed later.

The Dongjun Fm. is a freshwater limestone that was recognized as distinct from the Naduo Fm. in 1977. Although the Dongjun Fm. is mainly composed of gray and white limestone and limestone-pebble beds, it also contains purplish sandy mudstone and marly clay, the whole with a thickness of 50 m. The fossils occur mostly in the limestone-pebble beds, but also in the marly clays. The Dongjun Fm. disconformably overlies the Liuniu Fm. but crops out only in the southeast part of the Bose Basin. The lowermost part of this basin series is the "red stone" formation, or the Liuniu Fm., which consists of purplish red conglomerates, conglomeratic sandstone, sandstone, sandy mudstone and silt. It unconformably overlies Triassic rocks and, so far, has yielded no mammalian fossils. The few invertebrates found indicate that it is probably not older than the early Eocene.

The names of these formations are taken from

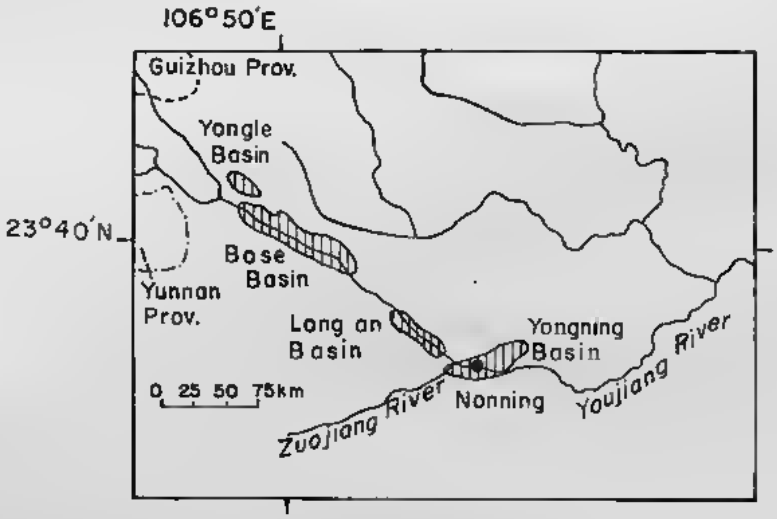


FIG. 40. — Outcrop map of the Tertiary basins of Guangxi showing the Bose, Yongle and Nanning Basins, Modified from Zhao, 1981.

1 Bose (= Baise); bai = 100; se = colors.
2 Yongle (= Yungle); yong = always; le = happy.

Source : MNHN, Paris

FIG. 41. — Sketch map of the Bose Basin in Guangxi Zhuangzu Autonomous Region. E_{1-2}: Liuniu Fm.; E_2^{2-3}: Dongjun and Naduo Fms.; E_2^3-E_3: Gongkang Fm.; the Tertiary sediments are surrounded by middle to late Triassic rocks. Modified from Tang *et al.*, 1974.

Source : MNHN, Paris

the local native language and put into Chinese form (and characters) and are difficult to translate.

Correlation of the Dongjun Fm. with that of the middle Eocene Irdin Manha fauna seems substantiated, but some elements (*Diplolophodon* and cf. *Gigantamynodon*) are more reminiscent of the late Eocene Shara Murun fauna.

Fauna of the Dongjun Fm.

PANTODONTA
- CORYPHODONTIDAE — *Eudinoceras crassum* Tong & Tang, 1977, V.P. (2)

CARNIVORA
- FELIDAE — *Eusmilus*? sp.; cited by Ding *et al.*, 1977, V.P. (1)

CONDYLARTHRA
- ARCTOCYONIDAE — *Andrewsarchus crassum* Ding. *et al.*, 1977, V.P. (1)

PERISSODACTYLA
- BRONTOTHERIIDAE — cf. *Protitan* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- BRONTOTHERIIDAE — *Metatelmatherium* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- DEPERETELLIDAE — *Diplolophodon* cf. *similis* Zdansky, 1930; cited by Ding *et al.*, 1977, V.P. (1)
- DEPERETELLIDAE — *Teleolophus* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- HYRACODONTIDAE — *Forstercooperia* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- HYRACODONTIDAE — *Prohyracodon* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- AMYNODONTIDAE — *Ilianodon*? sp.; cited by Ding *et al.*, 1977, V.P. (1)
- AMYNODONTIDAE — cf. *Gigantamynodon* sp.; cited by Ding *et al.*, 1977, V.P. (1)
- AMYNODONTIDAE — *Amynodon*[3] sp.; cited by Ding *et al.*, 1977, V.P. (1)
- AMYNODONTIDAE — cf. *Paramynodon* sp.; cited by Ding *et al.*, 1977, V.P. (1)

ARTIODACTYLA
- ANTHRACOTHERIIDAE — *Probrachyodus*? n. sp.; cited by Ding *et al.*, 1977, V.P. (1)

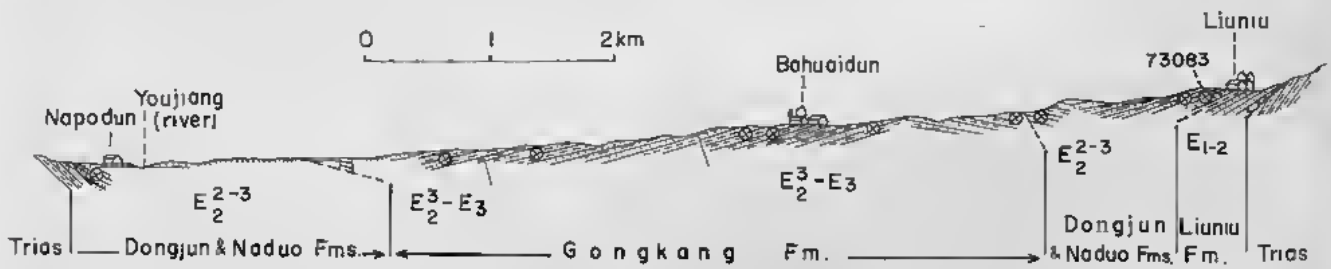


FIG. 42. — Cross section through the southeastern part of the Bose Basin, Guangxi. E_{1-2}, purplish red sandstone and conglomerate of the Liuniu Fm.; E_2^3-E_3, sandstone, sandy mudstone and mudstone of the Gongkang Fm. Middle to late Triassic sediments occur at each side. In the original version, locality 73083 was labeled " 73081 ". Modified from Tang *et al.*, 1974.

3 *Amynodon* is not cited in the revised lists presented by Xu, 1982, V.P. (4).

Source : MNHN, Paris

Lat. 34° 34′ N
Long. 110° 42′ E
(Lingbao City)

Fig. 2, n° 10

CHINA
HENAN PROVINCE
(Honan)
Lingbao Basin

Chuankou Fm. **middle Eocene**

Fossil vertebrates were found in the early 1960's in the Lingbao [4] Basin on the south bank of the Hoanghe about 50 km north of Lushi City by a geologist. IVPP members worked more extensively there in 1978 and divided the Cretaceous and early Tertiary sediments into four parts. The top formation, the Hunshuihe [5] Fm., is correlated with late Eocene faunas.

Underlying the Hunshuihe Formation is the Chuankou [6] Formation, which is made up of purplish red sandy clay and gravel; no thickness has been given for it.

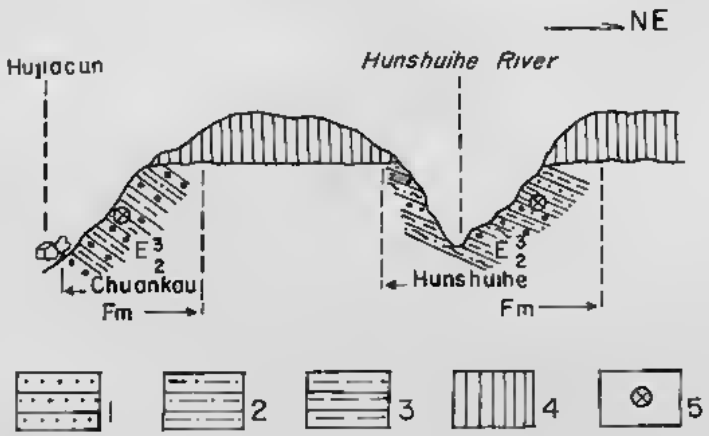


FIG. 43. — Cross section from Hujiacun through Hunshuihe in the Lingbao Basin, Henan. 1. sandstone; 2. sandy mudstone; 3. mudstone; 4. loess; 5. fossil mammal locality. Modified from Tong & Wang, 1980.

The lowest Tertiary deposit is called the Xiangcheng [7] Group. It consists of purplish red clay with sandstone and gravel. Higher in the section there appears a series of multicolored clays and sandstone; both contain marls and gravel, but fossils have nowhere been found. The thickness of the deposit varies from 700-800 m. It overlies the late Cretaceous Nanchao [8] Formation, in which dinosaur eggs have been discovered.

The Chuankou Formation could be either middle Eocene or late Eocene, according to the few mammalian fossils known from it. As no fossils have been discovered in the Xiangcheng Group, it is presumed to be Paleocene to early middle Eocene in age.

It is rumored that *Sianodon* has been found in the Chuankou Formation, but this is not confirmed.

4 Lingbao = place name.
5 Hunshuihe = troubled water river.
6 Chuankou = stream outlet.
7 Xiangcheng = Xiang City.
8 Nanchao = village name.

Source : MNHN, Paris

Fauna of the Chuankou Fm.

CREODONTA
HYAENODONTIDAE — cf. *Propterodon* sp.; cited by Tong & Wang, 1980, V.P. (1)
PERISSODACTYLA
BRONTOTHERIIDAE Indet. cited by Tong & Wang, 1980, V.P. (1)
HELALETIDAE — *Hyrachyus* sp.; cited by Chow *et al.*, 1973, V.P. (2); Tong & Wang, 1980, V.P. (1)

Lat. 34° 04′ N
Long. 110° 02′ E
(Lushi City)

Fig. 2, n° 11

CHINA
HENAN PROVINCE
(Honan)
Lushi Basin

Lushi Fm. **middle Eocene**
Locality: Mengjiapo

The Lushi [9] Basin is located on the northern slope of the Qinling [10] Mountains just north of the divide between north China and south China. The recovered fauna is essentially from a single locality (locality 57202, or Mengjiapo [11]). Nearly all the fossils are from a patch of sediments representing a sink-hole filling in the Sinian Precambrian limestone. Mengjiapo is about 1.5 km southwest of the county city of Lushi. The main body of the formation (about 450 m thick) consists of lacustrine beds of reddish and greenish marls or silty marls with basal conglomerates.

On the basis of his work during the summer of

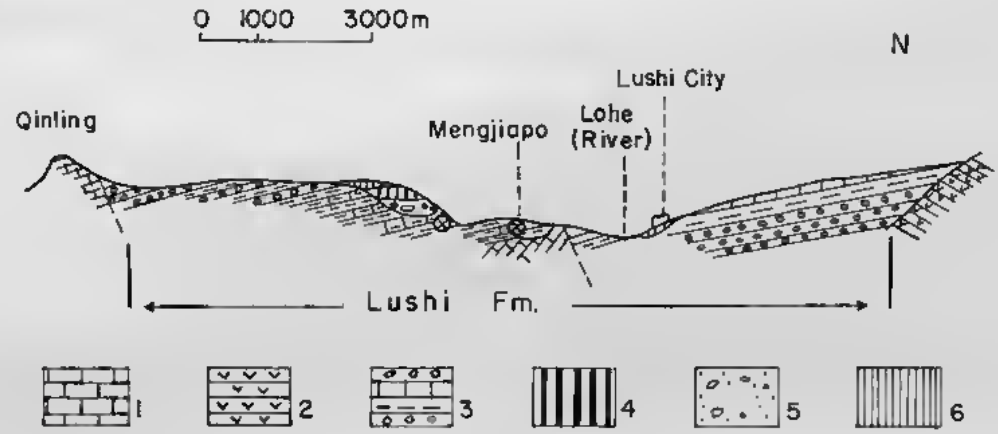


FIG. 44. — Cross section through the Lushi Basin, Henan. 1. Precambrian; 2. Jurassic; 3. Lushi Fm.; 4. Pliocene red clay; 5. Pliocene basal gravel; 6. loess. Modified from Chow *et al.*, 1973.

9 Lushi = Lu (family name) family.
10 Qinling (= Tsinglin = Tsingling).
11 Mengjiapo (= Menchiapu) = Meng (family name) slope.

Source : MNHN, Paris

1957, Chow called the sediments the Lushi fauna-bearing beds of the Lushi Basin. Later, the name Lushi Formation was used by Pei, Chow & Zheng (1960). At about the same time, members of the Beijing College of Geology studied the area and divided the overlying sediments into two formations; in the 1970's, these same beds received two other names by the 4th Geological Brigade of Henan. Field work in 1979 by Tong and Wang showed that the Henan geologists had misunderstood the article written by the geologists from Beijing and that the latter had misused place names. No fossils had been found by the geology crews. Tong and Wang kept the name of Lushi Formation for the bottom part of the series and proposed Chugouyu Formation for the fossiliferous beds overlying the Lushi. The highest formation (unfossiliferous and possibly Oligocene in age) retained the name Dayu Formation, previously given by Henan geologists.

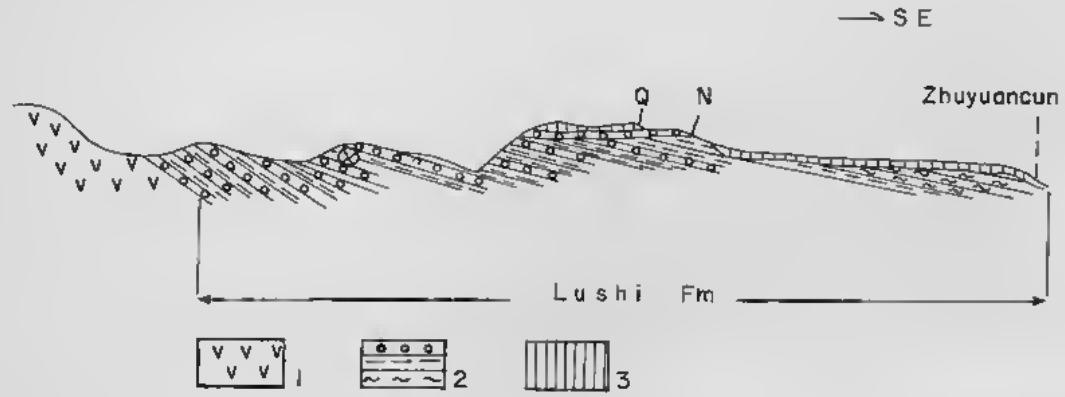


FIG. 45. — Cross section taken at Zhuyuancin, Lushi Basin, Henan, showing the lower level of the Lushi Fm. 1. Triassic; 2. Lushi Fm.; 3. loess; Q, Quaternary; N, Neogene. Modified from Tong & Wang, 1980.

The lower Tertiary of the Lushi Basin therefore includes the Chugouyu Formation (late Eocene) and the underlying Lushi Formation. Two units make up the Lushi Formation: the upper one (Chow's original Lushi Formation of 1957) is considered middle Eocene in age since its fauna bears a considerable resemblance to that of Irdin Manha; the lower one, recognized by Tong & Wang (1980), contains such mammals as *Eudinoceras*?, *Lophialetes*, and *Uintatherium* and also suggest that the age of these beds is middle Eocene.

Fauna of the Lushi Fm. (upper part)

TAENIODONTA
STYLINODONTIDAE — *Stylinodon*? sp.; cited by Chow *et al.*, 1973, V.P. (2)
(= Tillodontia gen. indet., sp. 2; cited by Chow, 1963, V.P. (2))

PRIMATES
FAMILY Indet. — *Lushius qinlinensis* Chow, 1961, V.P. (1)

PANTODONTA
CORYPHODONTIDAE — *Eudinoceras* sp.; cited by Chow *et al.*, 1973, V.P. (2)

LAGOMORPHA
LEPORIDAE — *Lushilagus lohoensis* Li, 1965, V.P. (1)

Source : MNHN, Paris

RODENTIA

CTENODACTYLIDAE [12] — *Tsinlingomys youngi* Li, 1963, V.P. (2)

CARNIVORA

MIACIDAE — *Miacis lushiensis* Chow, 1975, V.P. (3)
(= *Miacis* aff. *invictus* Matthew & Granger 1925e; cited by Chow *et al.*, 1973, V.P. (2))

CANIDAE — *Cynodictis* sp.; cited by Chow *et al.*, 1973, V.P. (2)

FELIDAE — cf. *Eusmilus* sp.; cited by Chow, 1958e.

CREODONTA

HYAENODONTIDAE — *Hyaenodon* sp.; cited by Chow *et al.*, 1973, V.P. (2)
— *Propterodon morrisi* (Matthew & Granger, 1924a) Van Valen, 1965b
(= *Paracynohyaenodon morrisi* Matthew & Granger, 1924a)
(= *Propterodon irdinensis* Matthew & Granger, 1925e; cited by Chow, 1975, V.P. (3))

CONDYLARTHRA

ARCTOCYONIDAE — *Paratriisodon henanensis* Chow, 1959b, V.P. (3) [13]
— *Andrewsarchus mongoliensis* Osborn, 1924b
(= *Paratriisodon gigas* Chow *et al.*, 1973, V.P. (2), *in* Van Valen, 1978)
(= *Paratriisodon* sp.; cited by Chow, 1959b, V.P. (3))

MESONYCHIDAE — *Honanodon hebetis* Chow, 1965, V.P. (3)
— *Honanodon macrodontus* Chow, 1965, V.P. (3)
— *Lohoodon lushiensis* (Chow, 1965) Chow *et al.*, 1973, V.P. (2)
(= *Hapalodectes lushiensis* Chow, 1965, V.P. (3))

PERISSODACTYLA

BRONTOTHERIIDAE — *Microtitan*? sp., (or new genus); cited by Chow *et al.*, 1973, V.P. (2)
— *Protitan grangeri* (Osborn, 1925) Granger & Gregory, 1943; cited as *Rhinotitan grangeri* by Chow *et al.*, 1973, V.P. (2)
(= *Protitanotherium grangeri* Osborn, 1925)

EOMOROPIDAE — *Eomoropus* sp.; cited by Chow *et al.*, 1973, V.P. (2)

CHALICOTHERIIDAE ? — *Lunania youngi* Chow, 1957a, V.P. (3); cited by Chow *et al.*, 1973, V.P. (2)

DEPERETELLIDAE — *Deperetella* sp.; cited by Chow *et al.*, 1973, V.P. (2)

HELALETIDAE — *Colodon* sp.; cited by Chow *et al.*, 1973, V.P. (2)

LOPHIALETIDAE — *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975
(= *Lophialetes minutus* Matthew & Granger, 1925f)
(= *Breviodon*? *minutus* Matthew & Granger, 1925f) Radinsky, 1965)

HYRACODONTIDAE — *Prohyracodon* sp.; cited by Chow *et al.*, 1973, V.P. (1)
— *Forstercooperia* spp.; cited by Chow *et al.*, 1973, V.P. (1)

AMYNODONTIDAE — *Lushiamynodon menchiapuensis* Chow & Xu, 1965, V.P. (2)
— *Sianodon honanensis* Chow & Xu, 1965, V.P. (2)
— *Caenolophus* sp.; cited by Chow *et al.*, 1973, V.P. (2)

ARTIODACTYLA

DICHOBUNIDAE — *Dichobune* sp.; cited by Chow *et al.*, 1973, V.P. (2)

ANTHRACOTHERIIDAE — *Anthracotherium* [14]? spp.; cited by Chow *et al.*, 1973, V.P. (2) — (questioned by the authors)

12 See footnote n° 11, p. 77.
13 This species may also be referable to *Andrewsarchus* (opinion of the authors).
14 This genus is everywhere else known only in the Oligocene. Its presence here is doubtful.

Source : MNHN, Paris

HELOHYIDAE [15] — *Gobiohyus orientalis* Matthew & Granger, 1925e; cited by Chow *et al.*, 1973, V.P. (2)
— *Gobiohyus robustus* Matthews & Granger, 1925e; cited by Chow *et al.*, 1973, V.P. (2)

Fauna of the Lushi Fm. (lower part)

PANTODONTA
CORYPHODONTIDAE — *Eudinoceras*? sp.; cited by Tong & Wang, 1980, V.P. (1)

DINOCERATA
UINTATHERIIDAE — *Uintatherium insperatus* Tong & Wang, 1981, V.P. (3)

DINOCERATA Indet; cited by Schoch & Lucas, 1985
(= Uintatheriinae indet.; cited by Tong & Wang, 1980, V.P. (1))

CONDYLARTHRA
MESONYCHIDAE Indet.; cited by Tong & Wang, 1980, V.P. (I)

PERISSODACTYLA
LOPHIALETIDAE — *Lophialetes* sp.; cited by Tong & Wang, 1980, V.P. (1)
— *Breviodon* sp.; cited by tong & Wang, 1980, V.P. (1)

ARTIODACTYLA
HELOHYIDAE — *Gobiohyus* sp.; cited by Tong & Wang, 1980, V.P. (1)

Lat. 32° 07′ N
Long. 114° 04′ E
(Xinyang City)

Fig. 2, n° 39

CHINA
HENAN PROVINCE
(Honan)
Pingchangguan Basin

Lizhuang Fm. **middle Eocene**
locality: Lizhuang

The Pingchangguan [16] Basin, in southermost Henan, was one of the ancient passes between north and south China. It covers an area of about 500 km^2. The continental sediments that accumulated in the basin were first referred to as "Lower Tertiary", but this was without any fossil evidence. The 12th Geological Brigade of Henan Province, in 1973-1975, discovered vertebrate fossils at Lizhuang [17], Minggang [18] Commune, and used them to divide the sediments into an

15 *Fide* Coombs & Coombs, 1977.
16 Pingchangguan = peaceful and prosperous pass.
17 Lizhuang (not Tuanshan as stated by Wang and Zhou (1982)) = Li's village.
18 Minggang = Bright port.

Source : MNHN, Paris

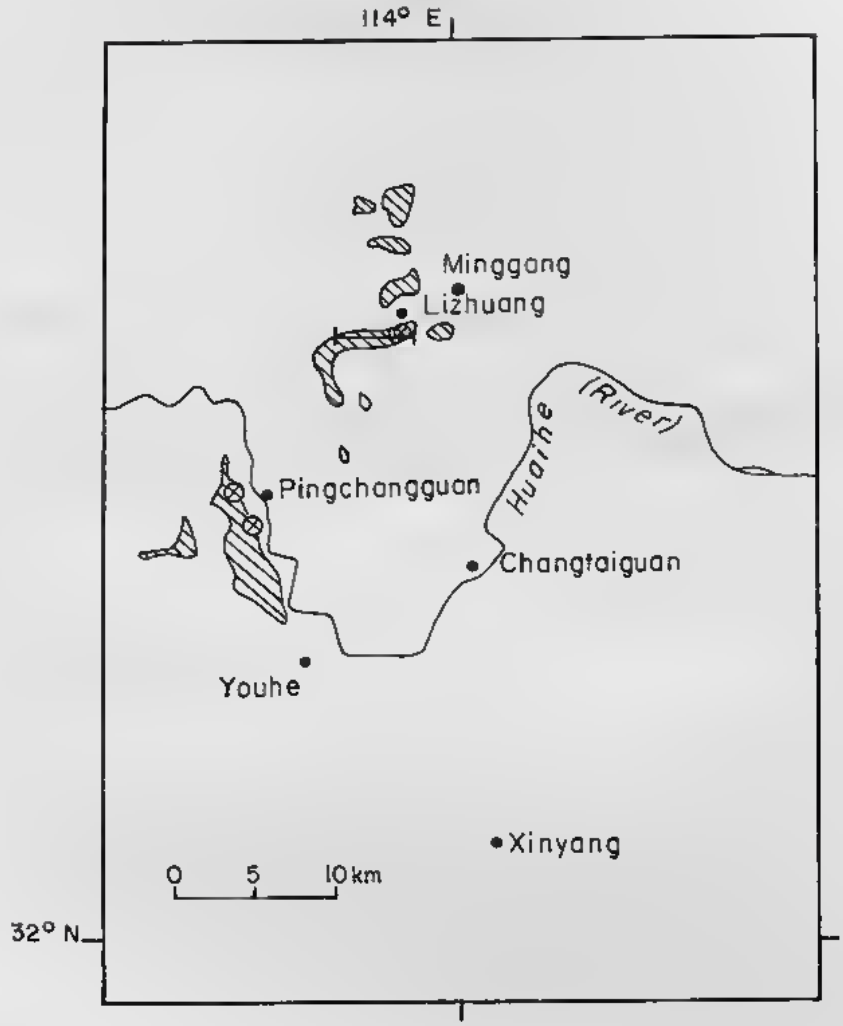


FIG. 46. — Sketch map of the Pingchangguan Basin, Henan, showing the outcrops (in hachures) of the Lizhuang Fm. Modified from Wang & Zhou, 1982.

early Cretaceous Chenpeng [19] Formation, a late Cretaceous Zhoujiawan [20] Formation, and the early Tertiary Lizhuang Formation.

The Lizhuang Formation crops out in patches in the northwestern part of the basin. It consists of gray and brownish red sandstone and conglomerate, and variegated sandstone, mudstone and conglomerate. Its thickness, measured between Yinzhuang [21] and Xumuchang [22], is 2,202 m. The bottom of the formation is not visible, so that the relationship between it and the underlying Zhoujiawan Formation is not known.

Breviodon cf. *minutus*, *Gobiohyus orientalis* and *Triplopus*? *proficiens* provide good correlation with the fauna of Irdin Manha. Wang and Zhou (1982) state that the Lizhuang Fm. is older than the three formations in the Wucheng Basin, two of which are suspected of extending into the middle Eocene, which also supports a middle Eocene age.

19 Chenpeng = Chen's (family name) shed.
20 Zhoujiawan = Zhou's (family name) river bend.
21 Yinzhuang = Yin's village.
22 Xumuchang = livestock farm.

Source : MNHN, Paris

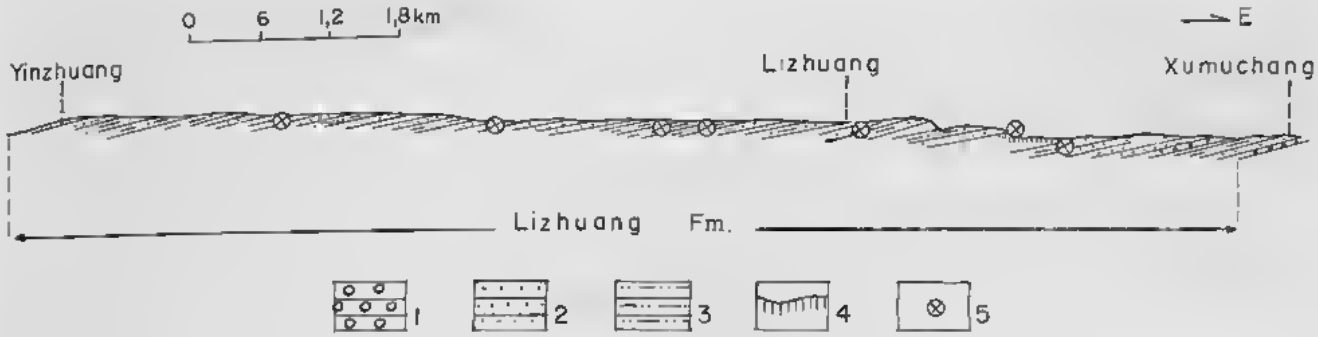


FIG. 47. — Cross section through the Lizhuang Fm. from Yinzhuang to Xumuchang (Minggang), Henan. 1. conglomerate; 2. sandstone; 3. argillaceous sandstone; 4. Recent covering; 5. fossil mammal locality. Modified from Wang & Zhou, 1981.

Fauna of the Lizhuang Fm.

RODENTIA

CTENODACTYLIDAE [23] — *Yuomys minggangensis* Wang & Zhou, 1982, V.P. (3)

CARNIVORA indet.; cited by Wang & Zhou, 1982, V.P. (3)

PERISSODACTYLA

LOPHIALETIDAE — *Breviodon* cf. *minutus* (Matthew & Granger, 1925f) Reshetov, 1975; cited by Wang & Zhou, 1982, V.P. (3)
(= *Lophialetes minutus* Matthew & Granger, 1925f)

HYRACODONTIDAE — *Triplopus*? cf. *proficiens* (Matthew & Granger, 1925f) Radinsky, 1967; cited by Wang & Zhou, 1982, V.P. (3)
(= *Caenolophus proficiens* Matthew & Granger, 1925f)
— Hyracodontidae indet.; cited by Wang & Zhou, 1982, V.P. (3)

RHINOCEROTIDAE indet.; cited by Wang & Zhou, 1982, V.P. (3) (doubted by the authors)

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Anthracokeryx* sp.; cited by Wang & Zhou, 1982, V.P. (3)
— Anthracotheriidae indet.; cited by Wang & Zhou, 1982, V.P. (3)

HELOHYIDAE — *Gobiohyus orientalis* Matthew & Granger, 1925e; cited by Wang & Zhou, 1982, V.P. (3)
— *Gobiohyus*? *minor* Wang & Zhou, 1982, V.P. (3)

ARTIODACTYLA Indet.; cited by Wang & Zhou, 1982, ibid.

23 See footnote n° 11, p. 77.

Source : MNHN, Paris

Lat. 32° 25′ N
Long. 113° 30′ E
(Wucheng Town)

Fig. 2, n° 14

CHINA
HENAN PROVINCE
(Honan)
Wucheng Basin

Lishigou and Maojiapo Fms. **middle Eocene**
Locality: Tongbai [24] Region

The Wucheng Basin is situated in southern Henan to the south and east of the cluster of similar small intermontane basins described above. The first Paleogene vertebrate fossils discovered here were found by the Henan 12th Geological Brigade in 1972. In 1973 an IVPP team worked in the basin, adding considerably to what was known. The 12th Geological Brigade divided the early Tertiary deposits of the basin into 3 formations. The top one is the Wulidui [25] Formation, which will be discussed later.

The Lishigou [26] Formation is made up of

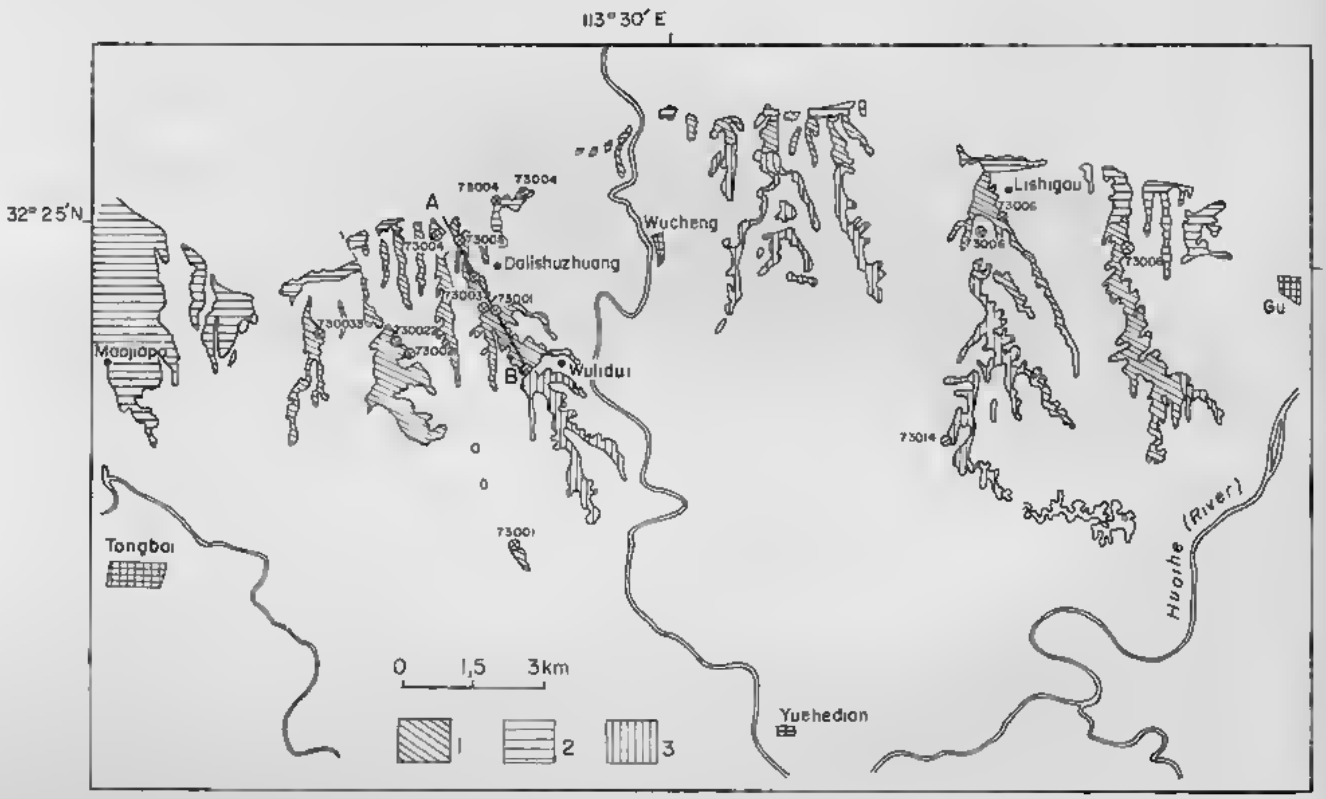


FIG. 48. — Outcrop map showing the Paleogene deposits of the Wucheng Basin, Henan. **1.** Lishigou Fm.; **2.** Maojiapo Fm.; **3.** Wulidui Fm. Modified from GAO, 1976.

24 Tongbai (= Dongbai = Tongbo).
25 Wulidui = wu = 5; li = a unit of distance equal to 1/2 km; dui = pile, or heap; the 5 li pile.
26 Lishigou = Lishi (Li family) Valley.

Source : MNHN, Paris

brown and yellow sandstone containing gravel and grayish green sandy clay with layers of marl, and towards the middle of the formation appear several beds of brick red, thick, sandy clays and marls. Its thickness is 370 m.

The bottom, or Maojiapo [27] Formation has sand, gravel, sandy clay or marls at its top, brick red sand and gravel in the middle and grayish red gravel at the bottom. In the north of the basin its thickness is 100 m, but it attains 350 m at the western part.

This series is underlain by Sinian metamorphic rocks; what overlies is not stated. There is little or no evident distinction between the 3 formations; lithologically, they are essentially continuous. This being the case, the bottom formation, the Maojiapo Formation, whose age is not clear (being based on a single edentulous jaw referred to *Deperetella*), could be either middle Eocene or the same age as the Lishigou Formation (or even part of the latter). This Lishigou Formation correlates approximately with the Irdin Manha Formation.

FIG. 49. — Section taken through localities 73004 and 73007 (A-B) in the Wucheng Basin, Henan. 1. sandstone; 2. siltstone; 3. conglomerate; 4 mudstone; 5. fossil mammal locality. Modified from GAO, 1976.

Fauna of the Lishigou Fm.

RODENTIA

CTENODACTYLIDAE [28] — *Yuomys eleganes* Wang, J., 1978, V.P. (1)
(= *Yuomys* sp. nov.; cited by GAO, 1976, V.P. (1))

CARNIVORA indet.; cited by GAO, 1976, V.P. (2)

CREODONTA

HYAENODONTIDAE — *Hyaenodon* sp.; cited by GAO, 1976, V.P. (1)
— Hyaenodontidae indet.; authors' opinion
(= gen. et sp. nov.; cited by GAO, 1976, V.P. (1)

PERISSODACTYLA

EOMOROPIDAE — *Eomoropus* sp.; cited by GAO, 1976, V.P. (1)

DEPERETELLIDAE — *Deperetella* sp.; cited by GAO, 1976, V.P. (1)

LOPHIALETIDAE — *Breviodon* sp.; cited by GAO, 1976, V.P. (1), as *Breviodon*? sp.
— Lophialetidae n. gen. et sp.; cited by GAO, 1976, V.P. (2)

HYRACODONTIDAE — *Pappaceras* sp.; cited by Wang, J., 1976, V.P. (2)
(= *Forstercooperia* sp.; cited by GAO, 1976, V.P. (1) [29]

27 Maojiapo = Mao (Mao family) Slope.
28 See footnote n° 11, p. 77.
29 Although *Forstercooperia* has been recognized to include this genus, Wang (1976) refutes this opinion. Zhai believes that forms attributed to *Pappaceras* are primitive within *Forstercooperia* and may really represent a different genus. A similar situation occurs with *Imequincisoria*; it does differ from *Pappaceras* and *Forstercooperia* but whether or not it differs enough to assure its validity is not certain.

Source : MNHN, Paris

AMYNODONTIDAE
— *Lushiamynodon wuchengensis* Wang, J., 1978, V.P. (1)
(= *Lushiamynodon* n. sp.; cited by GAO, 1976, V.P. (1)
— *Sharamynodon mongoliensis* (Osborn, 1936) Kretzoi, 1942
(= *Amynodon mongoliensis* Osborn, 1936; cited by Wang, J., 1978, V.P. (1)
(= *Sianodon* n. sp. and *Sianodon* sp.; cited by GAO, 1976, V.P. (1))
— *Sianodon sinensis* (Zdansky, 1930) Chow & Xu. 1965, V.P. (2)
(= *Amynodon sinensis* Zdansky, 1930; cited by Wang, J., 1978, V.P. (1))
— *Sianodon* sp.; cited by GAO, 1976, V.P. (1)

Fauna of the Maojiapo Fm.

PERISSODACTYLA
DEPERETELLIDAE — *Deperetella* sp.; cited by GAO, 1976, V.P. (I)

Lat. 32° 45′ N
Long. 110° 40′ - 111° 20′ E
(Liquanqiao Town = 32° 46′ N, 111° 27′ E)

Fig. 2, n° 13

CHINA
HENAN PROVINCE
(Honan)
Xichuan Basin

Dacangfang Fm. **middle Eocene**

The history of the discoveries in the Xichuan Basin was related in the chapter on the early Eocene Yuhuangding Formation.

The lower part of the Dacangfang Formation consists of alternating beds of sandstone and indurated gravels; higher in the section the sandstone becomes thin and the gravel disappears. Near the top of the formation green and gray clays appear. Gypsum is known in this formation. Total thickness is about 600 m.

Correlation of the formation is based in part on its position in a sequence between the later middle Eocene Hetaoyuan Formation and the early Eocene Yuhuangding Formation. Also, the presence of a very small and primitive amynodont adds weight to its designation as middle Eocene, but, as yet, there is not much faunal evidence.

Fauna of the Dacangfang Fm.

PANTODONTA
CORYPHODONTIDAE Indet.; cited by Xu *et al.*, 1979
RODENTIA
CTENODACTYLIDAE[30] Indet. (= "SCIURAVIDAE?"); cited by Xu *et al.*, 1979

30 According to Wood (1977) the various references to Sciuravidae in Asia are incorrect.

Source : MNHN, Paris

CONDYLARTHRA

MESONYCHIDAE Indet.; cited by Xu *et al.*, 1979

PERISSODACTYLA

BRONTOTHERIIDAE — cf. *Palaeosyops* sp.; cited by Xu *et al.*, 1979

LOPHIALETIDAE — *Lophialetes* sp.; cited by Teilhard de Chardin, 1930; by Radinsky, 1965; and by Chow *et al.*, 1973 (with a question mark, in the faunal list of the Hetaoyuan Fm.)

— Lophialetidae? indet.; cited by Xu *et al.*, 1979

AMYNODONTIDAE — *Caenolophus minimus* (Xu *et al.*, 1979) Wall & Manning, 1986 (= *Euryodon minimus* Xu *et al.*, 1979)

Lat. 32° 45′ N
Long. 110° 40′ - 111° 20′ E
(Liquanqiao Town = 32° 46′ N, 111° 27′ E)

Fig. 2, n° 13

CHINA
HENAN PROVINCE
(Honan)
Xichuan Basin

Hetaoyuan Fm. **middle Eocene**
Locality: Hetaoyuan

The sediments of this basin were discussed with the early Eocene Yuhuangding Formation (p. 75).

The highest formation in the series is the Hetaoyuan [31] Formation; it is composed mainly of green and gray clays, with some thin beds of marl. Towards the top, red clays appear. Its total thickness is about 500 m. The formation forms the top of the series; it is underlain by the Dacangfang Formation, also placed in the middle Eocene.

Elements of its fauna suggest that it is approximately equivalent to the Irdin Manha middle Eocene assemblage.

Fauna of the Hetaoyuan Fm.

TAENIODONTA

FAMILY Indet. — *Chungchienia sichuanica* Chow, 1963b, (referred to the Taeniodonta by Ding, 1979, V.P. (1))

RODENTIA

CTENODACTYLIDAE Indet. cited by Dawson *et al.*, 1984
(= *Sciuravus* sp.; cited by Li, 1963, V.P. (2); GAO, 1976 V.P. (1))
(= *Sciuravus*? sp.; cited by Xu *et al.*, 1979)

CARNIVORA

MIACIDAE — *Miacis lushiensis* Chow, 1975; cited by Xu *et al.*, 1979
(= *Miacis* aff. *invictus* Matthew & Granger, 1925e; cited by Chow *et al.*, 1973, V.P. (2) and by GAO, 1976, V.P. (1))

31 Hetaoyuan = walnut tree orchard.

Source : MNHN, Paris

CREODONTA
- OXYAENIDAE — *Prolaena parva* Xu *et al.*, 1979
- HYAENODONTIDAE — "*Sinopa*?" sp.; cited by GAO, 1976, V.P. (1)
- — *Tritemnodon* sp.; cited by GAO, 1976, V.P. (1)

CONDYLARTHRA
- ARCTOCYONIDAE — *Andrewsarchus*? sp.; cited by GAO, 1976, V.P. (1)

PERISSODACTYLA
- BRONTOTHERIIDAE — *Protitan*? sp.; cited by Xu *et al.*, 1979
- DEPERETELLIDAE — *Deperetella sichuanensis* (Xu *et al.*, 1979) Tong & Lei, 1984, V.P. (4) (= *Teleolophus sichuanensis* Xu *et al.*, 1979) (= *Deperetella* n. sp.; cited by GAO, 1976, V.P. (1))
- — *Teleolophus danjiangensis* Tong & Lei, 1984, V.P. (4) (= *Teleolophus* cf. *medius* Matthew & Granger, 1925f; cited by Xu *et al.*, 1979)
- — *Pachylophus xui* Tong & Lei, 1984, V.P. (4)
- (HELALETIDAE — *Colodon* sp. was cited in error by GAO, 1976, V.P. (1))
- LOPHIALETIDAE — *Schlosseria hetaoyuanensis* Tong & Lei, 1984, V.P. (4) (= *Lophialetes expeditus* Matthew & Granger, 1925f; cited by Xu *et al.*, 1979)
- — *Lophialetes* sp.; cited by GAO, 1976, V.P. (1), but not by Xu *et al.*, 1979
- — *Breviodon minutus* (Matthew & Granger, 1925f); cited by Tong & Lei, 1984, V.P. (4)
- — *Breviodon* cf. *minutus* (Matthew & Granger, 1925f); cited by Chow *et al.*,1973, V.P. (2) and by Xu *et al.*, 1979 as *Lophialetes* cf. *minutus*
- HYRACODONTIDAE — *Prohyracodon* sp.; cited by Xu *et al.*, 1979
- AMYNODONTIDAE — *Sianodon* sp.; cited by Xu *et al.*, 1979

Lat. 30° 24' N
Long. 111° 27' E
(Yidu City)

Fig. 2, n° 35

CHINA
HUBEI PROVINCE
(Hupeh)
Yidu District

Pailoukou Fm. **middle(?) Eocene**

Localities: Yangqi and Meiziqi

In 1934, Teilhard and Young located at Yangqi [32] a bone bed in the sandstone which is now called the Pailoukou [33] Formation. Early in 1936, L. P. Chia was sent to further investigate the locality. As the result of Chia's work a fragmentary skull of *Eudinoceras* was found. This is the first determinable specimen of that animal recovered in the formation. By the end of

32 Yangqi (= Yangchi) = Yang (place name) Creek.
33 Pailoukou = entrance of the decorated archway.

Source : MNHN, Paris

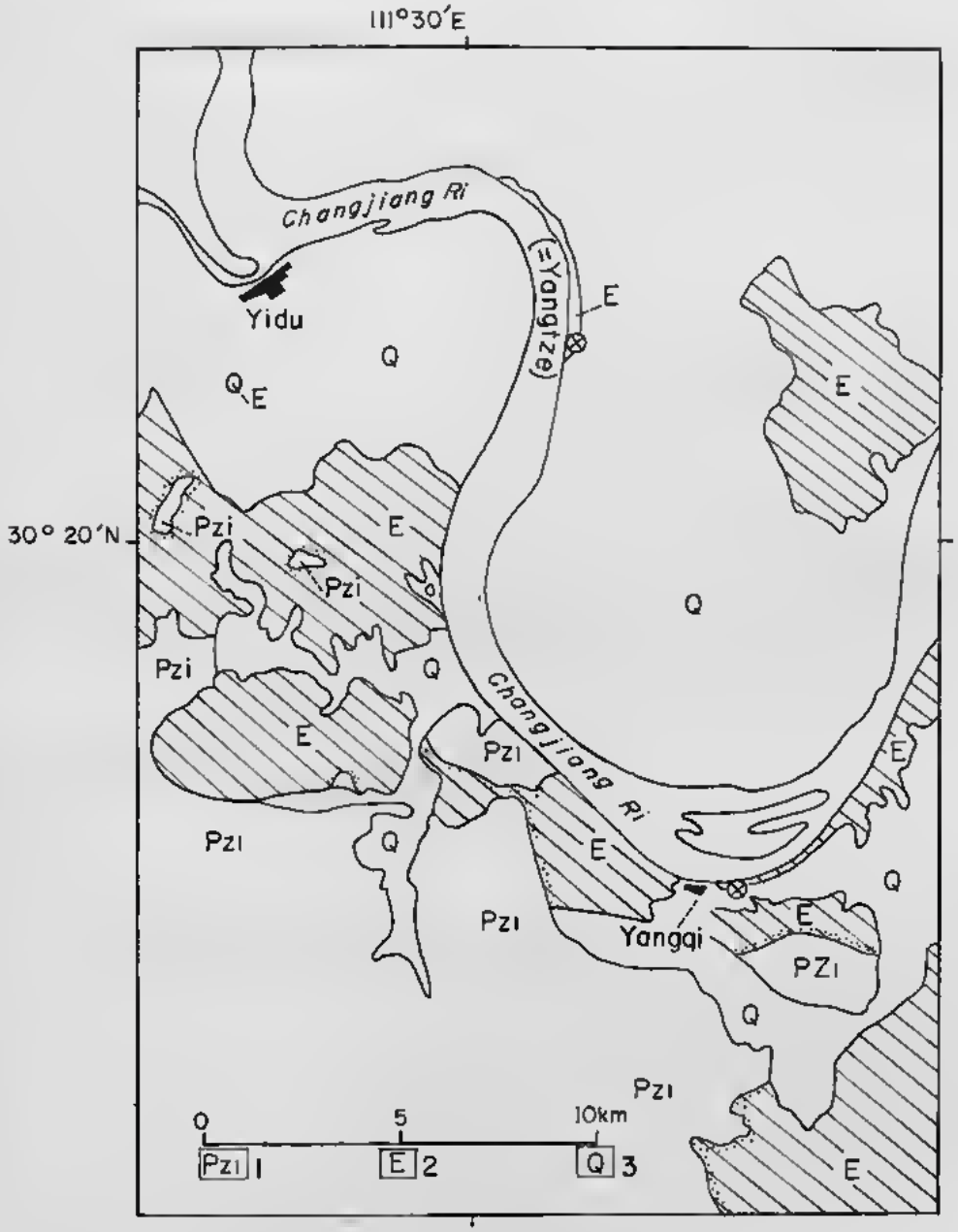


FIG. 50. — Geological map of the Yidu District, Hubei. 1. early Paleozoic; 2. Paleogene, middle? Eocene Pailoukou Fm.; 3. Quaternary. From a map provided by Lei Y.-z.

the 1970's the second one was found in the same formation at Meiziqi [34]. It is said (Lei Yizhen, pers. com.) that a third was discovered in the spring of 1981.

The Pailoukou Formation consists mainly of thick-layered sandstone and siltstone. It is grayish white, brownish red and grayish yellow in color. In its basal part there are muddy gravels. It underlies conformably the Yangqi Formation and is overlain by Quaternary sediments. Determinable fossil mammals were found only in the lower part. At the Pailoukou section the measured thickness of the formation is 447 m.

Correlation of this formation is difficult: its designation as middle Eocene is provisional. The coryphodont is similar to that of the Yuhuangding Fm. in the Xichuan Basin.

34 Meiziqi = Plum Creek.

Source : MNHN, Paris

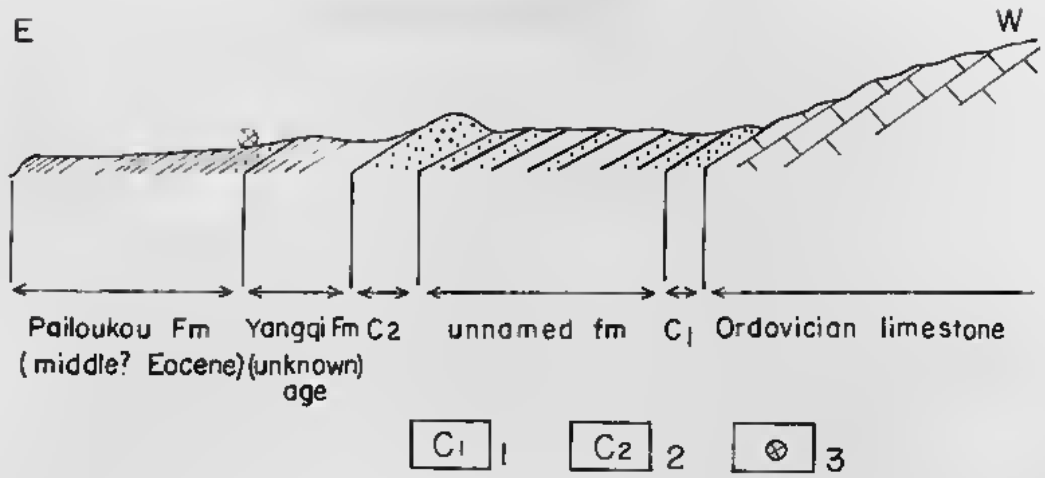


FIG. 51. — Cross section of early Cenozoic sediments near Yangqi, Yidu District, Hubei. This section was erroneously said to be near Yichang (= Ichang) which is about 60 km to the north of Yangqi. **1.** C1, the " first " conglomerate, overlying a weathered soil; **2.** C2, the " second " conglomerate; **3.** fossil mammal locality. What was termed the " Ichang " sandstone is now regarded as an unnamed formation; the Yangqi Fm. was formerly called the " Yangchi " lacustrine limestone. Modified from Teilhard de Chardin & Young, 1935.

Fauna of the Pailoukou Formation
Locality: Meiziqi

PANTODONTA

CORYPHODONTIDAE — *Eudinoceras youngi* (Xu, 1980) Lucas, 1982
(= *Manteodon youngi*, Xu, 1980, V.P. (4))
(= *Manteodon meizixiensis* Yan, *nomen nudum*)

Locality: Yangqi

PANTODONTA

CORYPHODONTIDAE — *Eudinoceras youngi* (Xu, 1980) Lucas, 1982
(= *Manteodon youngi*, Xu, 1980, V.P. (4))
(= *Eudinoceras* cf. *kholobolchiensis* Osborn & Granger, 1931; cited by Teilhard and Young, 1936)

Source : MNHN, Paris

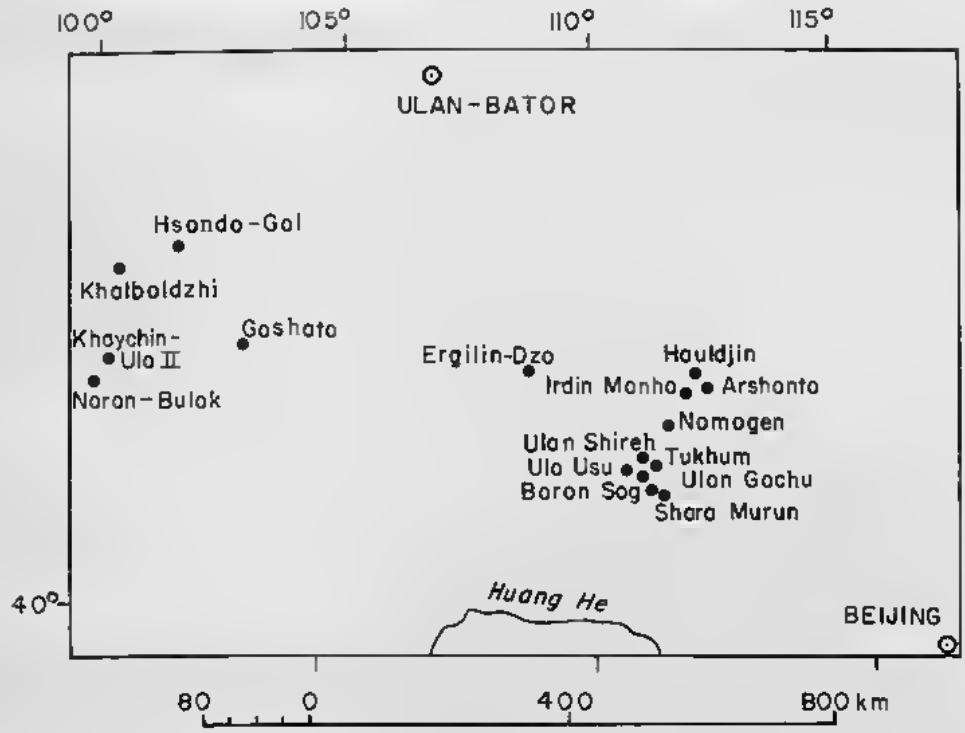


FIG. 52. — Sketch showing the distribution of the principal Paleogene fossil mammal localities of Inner (Nei Mongol) and outer Mongolia. Modified from Berkey, Granger & Morris, 1929.

Lat. 43° 30′ N, approx.
Long. 112° 15′ E, approx.

Fig. 2, n° 4

CHINA

NEI MONGOL AUTONOMOUS REGION

Sunid Zuoqi

Arshanto Fm. **middle Eocene**

Locality: Arshanto

The type section of the first named middle Eocene formation found in Asia is located near the Arshanto well, about 30 km SSE from the town of Erenhot [35] in the northwestern part of Sunid Zuoqi [36]

Lithologically, the Arshanto Formation is a sequence of dark reddish sandy clays and silts. It underlies the Irdin Manha Formation and, in its type section, is separated from it by an erosional surface. Since the first discovery of fossil mammals in this formation until recently, a total of only two forms, *Schlosseria* and *Teilhardia*, had been found (and the latter came from the " Tukhum " Formation, a lateral equivalent of the Arshanto); furthermore, it was thought that they were products of surface collecting and derived from the overlying Irdin Manha Formation. In recent years, in fact, *Schlosseria* has been found in place in the Irdin Manha beds.

The Nomogen Formation was established

35 Erenhot = Iren (but not Iren Dabasu, which is a different place) = Erlien = Ehrlien.
36 Sunid Zuoqi = Sunid (place name); Zuo = left; qi = administrative unit, equivalent to county. There are two Sunid Qi, one is Sunid Zuoqi (Left Qi), the other is Sunid Youqi (Right Qi).

Source : MNHN, Paris

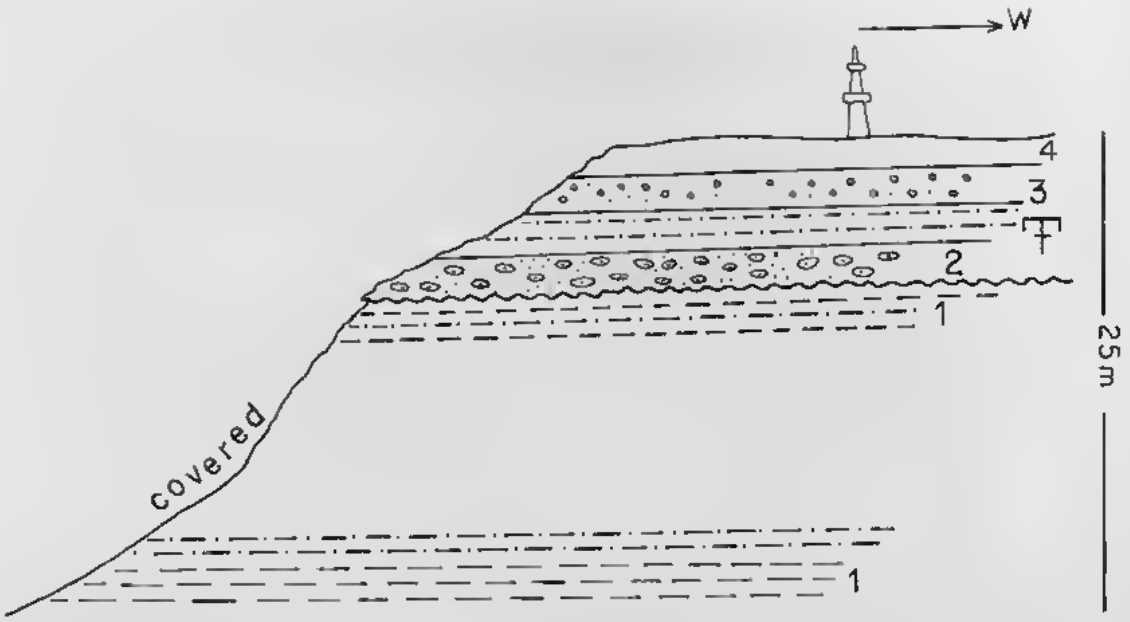


FIG. 53. — Cross section taken at the Arshanto escarpment, Nei Mongol. Arshanto Fm.: 1. dark red sandy clays. Irdin Manha Fm.: 2. light gray and green conglomerates which yielded the lower jaw of *Forstercooperia grandis* (= " *Pappaceras confluens* "; 3. grayish green sandstones with gravel; 4. Houldjin Gravels. Much of the Arshanto Fm. is covered at this site. Modified from Zhou *et al.*, 1976.

(type section at Haliut about 100 km southwest of Arshanto well) and shown to contain a fauna of late Paleocene mammals. In the general region, the Tertiary sequence consists of Nomogen Formation and overlying Irdin Manha Formation (also called the Ali-Usu Formation by local geologists); Arshanto is absent. In a preliminary article (by Zhou *et al.*, 1976), based on results found in 1975, it was suggested that the Nomogen and the Arshanto were one and the same thing, but additional field work done in 1976, wherein the Arshanto beds were traced southward and westward, showed that the Arshanto Formation disappears in this direction. Abundant collections were made in the Arshanto Formation at various places (including the Camp Margetts region and at Bayn Ulan) and the real nature of the Arshanto Formation was revealed, as well as the distinctiveness of the Nomogen Formation. Now for the first time, an Arshanto fauna is known. It should be noted that this Arshanto fauna is very similar to that of Ulan Shireh and Irdin Manha.

Fauna of the Arshanto Formation

INSECTIVORA

MICROPTERNODONTIDAE — *Sinosinopa sinensis* Qi, 1979, *nomen nudum*

PANTODONTA

PANTOLAMBDODONTIDAE — *Pantolambdodon* n. sp.
(= *Pantolambdodon? minor* Qi, 1979, *nomen nudum*)

CORYPHODONTIDAE — *Eudinoceras luminus* (Zhou & Qi, 1982) Lucas, 1982
(= *Metacoryphodon luminus* Zhou & Qi, 1982, V.P. (4))
(= *Metacoryphodon? luminus* Qi, 1979, *nomen nudum*)
— *Metacoryphodon? minor* Qi, 1979, *nomen nudum*

TILLODONTIA

TILLOTHERIIDAE n. gen., n. sp. (= *Ulanius chowi*, Qi, 1979, *nomen nudum*)

Source : MNHN, Paris

DINOCERATA
- UINTATHERIIDAE
  - — *Gobiatherium mirificum* Osborn & Granger, 1932
  - — *Gobiatherium* n. sp.
    (= *Gobiatherium major* Qi, 1979, *nomen nudum*)
    (= *Gobiatherium monolobotum* Qi, 1979, *nomen nudum*)

RODENTIA
- CTENODACTYLIDAE [37]
  - — *Tamquammys wilsoni* Dawson *et al.*, 1984

CARNIVORA
- — gen. & sp. indet.

CONDYLARTHRA
- MESONYCHIDAE
  - — *Mongolonyx* n. sp.
    (= *Mongolonyx prominentis* Qi, 1979; *nomen nudum*)
  - — *Mesonyx*? n. sp.
    (= *Mesonyx? obtusidens* Qi, 1979, *nomen nudum*)

PERISSODACTYLA
- BRONTOTHERIIDAE
  - — *Microtitan* sp.
  - — *Microtitan*? n. sp.
    (= *Microtitan*? *elongatus* Qi, 1979; *nomen nudum*)
  - — *Desmatotitan* sp.
- DEPERETELLIDAE
  - — *Teleolophus* n. sp.
    (= *Teleolophus primarius* Qi, 1979, *nomen nudum*)
    (= *Teleolophus rectis* Qi, 1979, *nomen nudum*)
- HELALETIDAE
  - — *Colodon* cf. *inceptus* Matthew & Granger 1925c
  - — *Hyrachyus* n. sp.
    (= *Hyrachyus neimongoliensis* Qi, 1979, *nomen nudum*)
    (= *Hyrachyus crista* Qi, 1979, *nomen nudum*)
    (= *Hyrachyus medius* Qi, 1979, *nomen nudum*)
    (= *Hyrachyus*? *minor* Qi, 1979, *nomen nudum*)
- LOPHIALETIDAE
  - — *Lophialetes expeditus* Matthew & Granger, 1925f
  - — *Schlosseria magister* Matthew & Granger, 1926
  - — *Schlosseria* n. sp.
    (= *Schlosseria dimera* Qi, 1979, *nomen nudum*)
  - — *Breviodon*? *minutus* (Matthew & Granger, 1925f)
- HYRACODONTIDAE
  - — *Forstercooperia grandis*?, Peterson, 1919
  - — *Forstercooperia* n. sp.
    (= *Forstercooperia huhebolhensis* Qi, 1979, *nomen nudum*)
    (= *Forstercooperia elongata* Qi, 1979, *nomen nudum*)
  - — *Urtinotherium* n. sp.
    (= *Urtinotherium*? *minor* Qi, 1979, *nomen nudum*)
- (FAMILY not designated)
  - — *Euryletes magnus* Qi, 1979; *nomen nudum*
  - — *Euryletes minimus* Qi, 1979; *nomen nudum*
  - — *Euryletes medius* Qi, 1979; *nomen nudum*

37 See footnote n° 11, p. 77. Two taxa were given names by Qi (1979), *Maodengomys youngi* and *Asiamys medius (nomina nuda)*, but were not referred to families; it is not said in Dawson *et al.*, 1984, if *T. wilsoni* represents one of the *nomina nuda*.

Source : MNHN, Paris

Lat. 43° 30′ N, approx.
Long. 112° 15′ E, approx.

Fig. 2, n° 4

CHINA

Nei Mongol Autonomous Region

(Inner Mongolia)

Sunid Zuoqi

Irdin Manha Fm. **middle Eocene**

Locality: Irdin Manha

The originally designated Irdin Manha Formation was composed of a series of sands, clays and gravels forming a cliff in the region of Irdin Manha about 33 km SSE of Erenhot (Iren). The lower part of this series, consisting of red clays and silts, was later named the Arshanto Formation and the name Irdin Manha was restricted to the distinctively white, sandy clays, sands and gravels comprising the upper 10 m of the cliff. This formation is richly fossiliferous at the type locality, with most of the material coming from the lower part of the section. At the eastern border of the Camp Margetts region the Houldjin Gravels have been reported to disconformably overlie the Irdin Manha Formation, but McKenna (pers. com., 1985) maintains that these upper sediments are also referable to the Irdin Manha Formation and have furnished remains of *Lophialetes* from the cliffs east of Erenhot.

Large collections were made in the (restricted) Irdin Manha Formation in 1922 and 1923 by American Museum parties and another in 1959 by the Sino-Soviet expedition. The IVPP, alone, also collected here in the 1970's. It is probable that there are a few elements in the AMNH collection that do not come from the Irdin Manha Formation. Those collected along the escarpment between the type section of the Arshanto Formation and Irdin Manha are probably accurately identified as to level, but in the Camp Margetts region, where the stratigraphy is more complicated, a mixture may have been made. *Gobiatherium mirificum*, for example, has been found to be confined to the Arshanto Formation by Chinese teams. *Mongolonyx dolichognathus* might also be only from the Arshanto Formation. Other forms are now known from both the Arshanto and the Irdin Manha Formations, such as *Lophialetes expeditus* and *Schlosseria magister*.

A detailed explanation of the reasoning behind the referral of the Irdin Manha assemblage to the middle Eocene is given in the Conclusion.

Fauna of the Irdin Manha Formation at Sunid Zuoqi

INSECTIVORA

Pantolestidae Indet.; cited by Manning, pers. com., 1977
(= *Pantolestes*? sp.; cited by Matthew & Granger, 1924b)
(= *Pantolestes* sp.; cited by Belyayeva *et al.*, 1974)

PANTODONTA

Coryphodontidae — *Eudinoceras mongoliensis* Osborn, 1924a

RODENTIA

Paramyidae — gen. and sp. indet.; cited by Li, 1963, V.P. (2) and by Dawson, 1964

CARNIVORA

Miacidae — *Miacis invictus* Matthew & Granger, 1925e

CREODONTA

Hyaenodontidae — *Propterodon morrisi* (Matthew & Granger, 1924a) Van Valen, 1965b
(= *Paracynohyaenodon morrisi* Matthew & Granger, 1924a)
(= *Propterodon irdinensis* Matthew & Granger, 1925e)

Source : MNHN, Paris

CONDYLARTHRA

ARCTOCYONIDAE
— *Andrewsarchus mongoliensis* Osborn, 1924b

MESONYCHIDAE
— *Hapalodectes serus* Matthew & Granger, 1925e
— cf. *Mesonyx* sp.; cited by Szalay & Gould, 1966
— cf. *Pachyaena* sp.; cited by Szalay & Gould, 1966
— Mesonychidae indet.; cited by Szalay & Gould, 1966

PERISSODACTYLA

BRONTOTHERIIDAE
— *Metatelmatherium parvum* Granger & Gregory, 1943
— *Microtitan mongoliensis* (Osborn, 1925) Granger & Gregory, 1943
(= *Metarhinus? mongoliensis* Osborn, 1925)
— *Gnathotitan berkeyi* Osborn, 1925
(= *Telmatherium berkeyi* Osborn, 1925
— *Epimanteoceras robustus* (Granger & Gregory, 1943) Yanovskaya *et al.*, 1977
(= *Protitan robustus* Granger & Gregory, 1943)
(= *Epimanteoceras amplus* Yanovskaya, 1976)
— *Protitan obliquidens* Granger & Gregory, 1943
— *Protitan grangeri* (Osborn, 1925) Granger & Gregory, 1943
(= *Protitanotherium grangeri* Osborn, 1925)
(= *Dolichorhinus olseni* Osborn, 1925)
(= *Manteoceras? irdinensis* Osborn, 1925)

DEPERETELLIDAE
— *Teleolophus medius* Matthew & Granger, 1925f

HELALETIDAE
— *Helaletes mongoliensis* (Osborn, 1923a) Radinsky, 1965
(= *Desmatotherium mongoliense* Osborn, 1923a)

LOPHIALETIDAE
— *Lophialetes expeditus* Matthew & Granger, 1925f
— *Lophialetes?* sp.; cited by Radinsky, 1965
— *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975
(= *Lophialetes minutus* Matthew & Granger, 1925f)
(= *Breviodon? minutus* (Matthew & Granger, 1925f) Radinsky, 1965)
(= *Breviodon acares* Radinsky, 1965, *in* Reshetov, 1975)
— *Simplaletes sujiensis* Qi, 1980b, V.P. (3)

LOPHIALETIDAE?
— *Rhodopagus pygmaeus* Radinsky, 1965
(= *Rhodopagus minimus* Matthew & Granger, 1925d, *in* Lucas & Schoch, 1981; denied by Radinsky, pers. com., 1984)

HYRACODONTIDAE
— *Triplopus? proficiens* (Matthew & Granger, 1925f), Radinsky, 1967
(= *Caenolophus proficiens* Matthew & Granger, 1925f)
— *Forstercooperia totadentata* (Wood, 1938) Wood, 1939
(= *Cooperia totadentata* Wood, 1938)

ARTIODACTYLA

LEPTOMERYCIDAE
— cf. *Archaeomeryx* sp.; cited by Matthew & Granger, 1925e

HELOHYIDAE [38]
— *Gobiohyus orientalis* Matthew & Granger, 1925e
— *Gobiohyus pressidens* Matthew & Granger, 1925e
— *Gobiohyus robustus* Matthew & Granger, 1925e

ORDER INDET.

DIDYMOCONIDAE
— *Mongoloryctes acutus* (Matthew & Granger, 1925e) Van Valen, 1966
(= *Hapalodectes? acutus* Matthew & Granger, 1925e)

38 In 1925e, Matthew & Granger cited a partial large upper molar as "Achaenodontidae" indet., but noted that its relationship to the Helohyidae could be much closer. Coombs & Coombs (1977) concur that, dentally, this tooth could well belong to the Helohyidae. Matthew & Granger cited the specimen as being from the Irdin Manha beds, but Radinsky (1964) corrected this, pointing out that it came from the sandstones that were sometimes referred to the Houldjin beds. McKenna (pers. com., 1985) is of the opinion that the Houldjin is equivalent to the Irdin Manha. In any case, the specimen is not entelodontid.

Source : MNHN, Paris

Lat. 43° 25′ N
Long. 111° 50′ E, approx.

Fig. 2, n° 3

CHINA

NEI MONGOL AUTONOMOUS REGION

(Inner Mongolia)

Irdin Manha Fm. **middle Eocene**

Locality: Camp Margetts Area (Huhebolhe Cliff)

This area is about 30 km WSW of the type Irdin Manha locality. It includes the AMNH locality 147 of 1923 and the six principal AMNH sites of 1930. The IVPP also collected here in 1977. But no region has posed more stratigraphic problems to recent workers. Some of these have been discussed by Radinsky (1965, 1967), who gave a section (in 1964b) and remarked that several other sections were made by American Museum crews, none of which agreed exactly with any other, and that even a different color sequence was observed for the sediments of each locality. He recommended that for the old collections " Irdin Manha " and " Houldjin " be placed in quotes when referring to deposits in the Camp Margetts area, as correlation is quite uncertain and the names were apparently used rather indiscriminately.

Qi (1980a) recognized three units at Huhebolhe[39] Cliff:

— the Irdin Manha Formation, 5 m thick and yielding 6 mammalian species;

— the Arshanto Formation, about 30 m thick, from which he collected his large new fauna (see under Arshanto);

— the Bayn Ulan (= Nomogen?) Formation, about 36 m thick, but not distinguishable lithologically according to McKenna (pers. com., 1985); " *Mongolotherium* " sp. (= *Prodinoceras*) was found here.

The mammals listed by Li & Ting (1983) are tentatively presumed to be from the Irdin Manha Formation.

Fauna of the Irdin Manha Formation in the Camp Margetts Area

PANTODONTA Indet.; cited by Qi, 1980a, V.P. (1)[40]

RODENTIA

PARAMYIDAE Indet.; cited by Li & Ting (1983)

CTENODACTYLIDAE[41] — *Advenimus burkei* Dawson, 1964

CONDYLARTHRA

ARCTOCYONIDAE — *Andrewsarchus mongoliensis* Osborn, 1924b
(= *Paratriisodon gigas* Chow *et al.*, 1973, V.P. (2), *in* Van Valen, 1978; cited by Qi, 1980, V.P. (1))

MESONYCHIDAE — *Mongolonyx dolichognathus* Szalay & Gould, 1966[42]

PERISSODACTYLA

BRONTOTHERIIDAE — *Metatelmatherium cristatum* Granger & Gregory, 1938
— *Protitan minor* Granger & Gregory, 1943
— *Protitan? cingulatus* Granger & Gregory, 1943
(= " ?Houldjin "; locality doubtful)

39 Huhebolhe = Fuhoborho; see Fig. 28.
40 Found by Qi in 1977, along with *Andrewsarchus* and *Lophialetes*.
41 See footnote n° 11, p. 77.
42 The type (this specimen) was found 25 miles west of Irdin Manha, and may have come from the Arshanto Fm.

Source : MNHN, Paris

EOMOROPIDAE	— *Litolophus gobiensis* (Colbert, 1934) Radinsky, 1964 (= *Grangeria gobiensis* Colbert, 1934)
DEPERETELLIDAE	— cf. *Teleolophus medius* Matthew & Granger, 1925f; cited by Radinsky, 1965
HELALETIDAE	— *Helaletes fissus* (Matthew & Granger, 1925f) Radinsky 1965 (= *Desmatotherium fissum* Matthew & Granger, 1925f)
	— *Helaletes fissus*? Matthew & Granger, 1925f; cited by Radinsky, 1965
	— *Helaletes* sp., cited by Radinsky, 1965
	— cf. *Hyrachyus* sp., cited by Radinsky, 1965
LOPHIALETIDAE	— *Breviodon*? sp., cited by Radinsky, 1965
	— *Lophialetes expeditus* Matthew & Granger, 1925f
	— cf. *Schlosseria magister* Matthew & Granger, 1926; cited by Radinsky, 1965
HYRACODONTIDAE	— *Forstercooperia grandis*, (Peterson, 1919) Radinsky, 1967 (= *Hyrachyus grande* Peterson, 1919) (= *Forstercooperia confluens* (Wood, 1963) Radinsky, 1967) (= *Pappaceras confluens* Wood, 1963)[43]
AMYNODONTIDAE	— *Rostriamynodon grangeri* Wall & Manning, 1986

Lat. 42° 30′ N, approx.
Long. 111° 00′ E, approx.

Fig. 2, n° 2

CHINA

NEI MONGOL AUTONOMOUS REGION

(Inner Mongolia)

Ulan Shireh Fm. **middle Eocene**

At North Mesa, in the area of the Ulan Shireh type section a few miles north of Tukhum Lamasery, there are exposed at least 50 m of multicolored, predominantly red clays; the poorly fossiliferous "Tukhum" Formation underlies them. There is little probability of there having been a mixture of faunas, although the "Tukhum" Formation is lithologically very similar. A light colored sandy formation overlies the Ulan Shireh Formation, but it is unfossiliferous and has received no name nor an age determination.

Both in 1925 and 1928 large collections of fossil vertebrates from the Ulan Shireh Formation were made by the American Museum; principal collecting sites include Buckshot's Quarry and Chimney Butte. Some specimens were obtained from this formation by the Sino-Soviet expedition in 1959 and from 1975 to 1981 the IVPP collected more material.

It should be mentioned that the Ulan Shireh Formation crops out only at North Mesa. It has nothing to do with Ulan Shireh Obo, East Mesa.

The Ulan Shireh fauna was extensively reviewed by Ye Jie in 1983. It was concluded that the assemblage was simply a taphocoenosis of the Irdin Manha fauna. Both were considered older than the Shara Murun and younger than the Arshanto fauna, but possessing a closer resemblance to the latter. This led to the suggestion of an early late Eocene age for the Ulan Shireh fauna, without, however, exclusion of the possibility of its being older.

43 The type specimen of this species was found 10 miles SW of Camp Margetts; its precise stratigraphic level is unknown.

Source : MNHN, Paris

Fauna of the Ulan Shireh Fm.

PANTODONTA

CORYPHODONTIDAE — *Eudinoceras mongoliensis* Osborn, 1924a

PANTOLAMBDODONTIDAE — *Pantolambdodon inermis* Granger & Gregory, 1934
(= *Pantolambdodon fortis* Granger & Gregory, 1934, *in* Lucas, 1982)

LAGOMORPHA

LEPORIDAE — *Shamolagus grangeri* Burke, 1941
— Palaeolaginae indet.; cited by Ye, 1983, V.P. (2)

RODENTIA

CTENODACTYLIDAE [44] — *Advenimus bohlini* Dawson 1964
— cf. *Advenimus* sp.; cited by Dawson, 1964
— *Yuomys weijingensis* Ye, 1983, V.P. (2)

CARNIVORA

MIACIDAE Indet.; cited by Ye, 1983, V.P. (2)

CANIDAE — cf. "*Cynodictis*"; cited by Manning, pers. com. 1977

CREODONTA

OXYAENIDAE — *Sarkastodon mongoliensis* Granger, 1938 [45]

HYAENODONTIDAE — cf. *Propterodon morrisi* (Matthew & Granger, 1924a) Van Valen, 1965b
(= *Paracynohyaenodon morrisi* Matthew & Granger, 1924a)
(= *Propterodon irdinensis* Matthew & Granger, 1925e, *in* Van Valen, 1965

CONDYLARTHRA

MESONYCHIDAE — *Hapalodectes serus*? Matthew & Granger, 1925e, doubted by Szalay, 1969
— *Harpagolestes? orientalis* Szalay & Gould, 1966
— cf. *Mesonyx* sp.; cited by Szalay & Gould, 1966
— gen. and sp. indet.; cited by Ye, 1983, V.P. (2)

PERISSODACTYLA

BRONTOTHERIIDAE — *Desmatotitan tukhumensis* Granger & Gregory, 1943
— *Acrotitan ulanshirehensis* Ye, 1983, V.P. (2)
— *Epimanteoceras formosus* Granger & Gregory, 1943
— *Protitan bellus* Granger & Gregory, 1943
— *Microtitan mongoliensis*? (Osborn, 1925) Granger & Gregory, 1943
(= *Metarhinus? mongoliensis* Osborn, 1925)
— *Dolichorhinoides angustidens* Granger & Gregory, 1943

DEPERETELLIDAE — *Teleolophus medius*? Matthew & Granger, 1925f; cited by Radinsky, 1965

LOPHIALETIDAE — *Lophialetes expeditus*? Matthew & Granger, 1925f; cited by Radinsky, 1965
— *Lophialetes* sp.; cited by Radinsky, 1965
— *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975
(= *Lophialetes minutus* Matthew & Granger, 1925f)
(= *Breviodon? minutus* (Matthew & Granger, 1925f) Radinsky, 1965)
(= *Breviodon acares* (Radinsky, 1965), Reshetov, 1975)

44 See footnote n° 11, p. 77.
45 This is the paratype specimen; the type was found in the Camps Margetts area, from an uncertain horizon.

Source : MNHN, Paris

— *Breviodon*? sp.; cited by Radinsky, 1965
— *Simplaletes ulanshirehensis* Qi, 1980, V.P. (3)
— *Schlosseria* cf. *magister* Matthew & Granger, 1926; cited by Manning, pers. com., 1977
— *Zhongjianoletes chowi* Ye, 1983, V.P. (2)
— *Zhongjianoletes*? sp.; cited by Ye, 1983, V.P. (2)

LOPHIALETIDAE? [46]
— *Rhodopagus minimus* (Matthew & Granger, 1925d) Lucas & Schoch, 1981b
(= *Rhodopagus? minimus* (Matthew & Granger, 1925d) Radinsky, 1965)
(= *Caenolophus? minimus* Matthew & Granger, 1925d)
— *Rhodopagus pygmaeus* Radinsky, 1965
(= *Rhodopagus minimus in* Lucas & Schoch, 1981b; denied by Radinsky, pers. com., 1984)

HYRACODONTIDAE
— *Forstercooperia* cf. *grandis* (Peterson, 1919); cited by Manning, 1977, as *Forstercooperia* cf. *confluens* (Wood, 1963)
(= *Forstercooperia grandis* (Peterson, 1919) Lucas *et al.*, 1981)
(= *Hyrachyus grande* Peterson, 1919)
(= *Forstercooperia confluens* Wood, 1963, *in* Radinsky, 1967)
(= *Pappaceras confluens* Wood, 1963)
— *Triplopus? proficiens* (Matthew & Granger, 1925f) Radinsky, 1967
(= *Caenolophus proficiens* Matthew & Granger, 1925f)

AMYNODONTIDAE
— *Lushiamynodon sharamurenensis* Xu, 1966, V.P. (2)

ARTIODACTYLA

HELOHYIDAE
— *Gobiohyus orientalis* Matthew & Granger, 1925e; cited by Manning, pers. com., 1977

ORDER Indet.

DIDYMOCONIDAE?
— *Kennatherium shirensis* Mellett & Szalay, 1968

Lat. 42° 30′ N, approx.
Long. 111° 45′ E, approx.

Fig. 2, n° 2

CHINA
NEI MONGOL AUTONOMOUS REGION
(Inner Mongolia)

"Tukhum" Fm. **middle Eocene**

Locality: Ula Usu

The hard red clays at the base of the section at Ula Usu [47] were at first called the "lower red beds" by American Museum workers, or referred to as the Arshanto beds. Later, they received the name Tukhum Formation. Only two taxa have been identified from this formation, *Teilhardia* (one specimen) and *Lophialetes* cf. *expeditus* (at least 5 individuals). Only *Lophialetes* is particularly useful, being found not only in the Arshanto Formation but also in the Irdin Manha. However, on the basis of lithology (dominant red clays) the formation is much more similar to

46 *Rhodopagus* was placed in the Hyracodontidae by Lucas & Schoch (1981b). Radinsky (pers. com., 1984) has argued that it would be better returned to the Tapiroidea as a questionable lophialetid.
47 Ula Usu = mountain water.

Source : MNHN, Paris

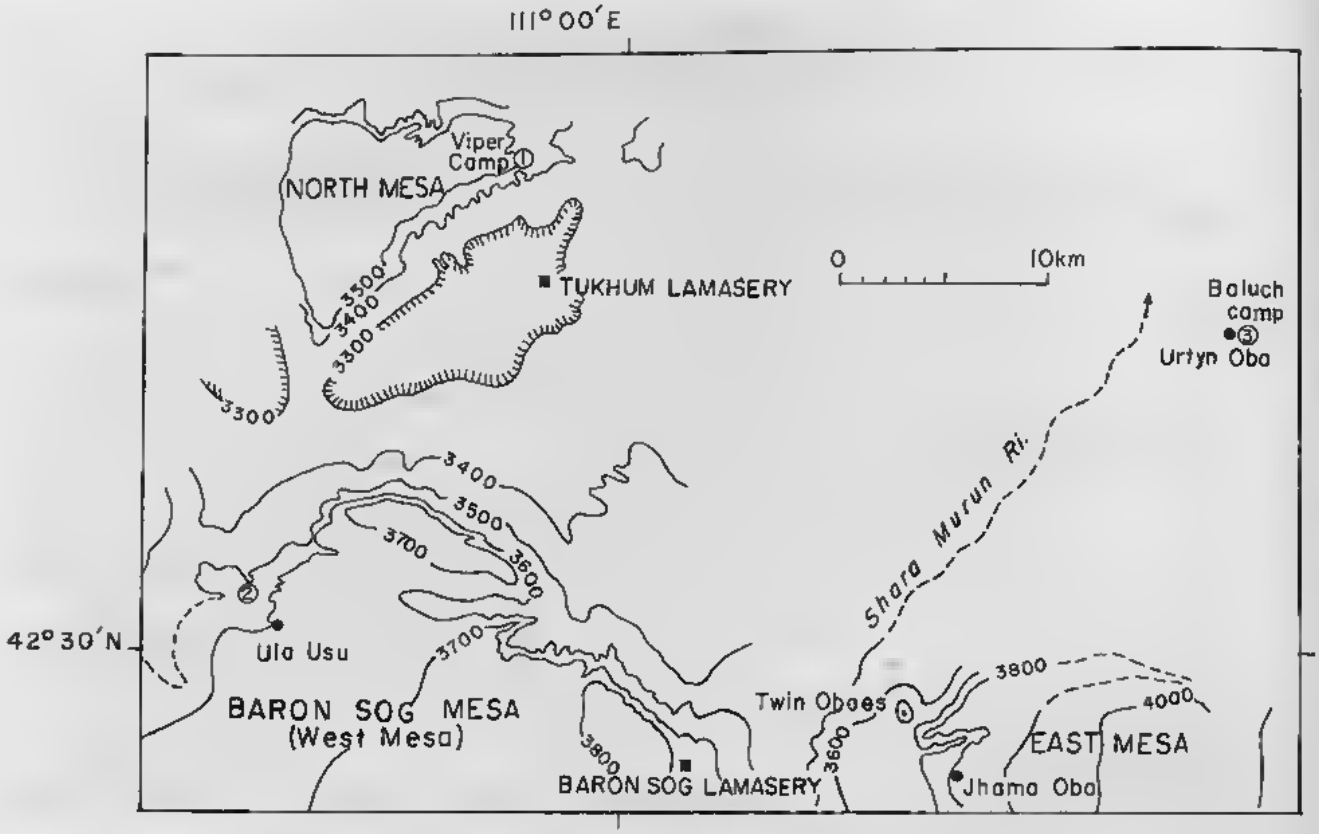


FIG. 54. — Sketch map of the Shara Murun region, Nei Mongol. 1. type section of the Ulan Shireh Fm.; 2. type section of the " Tukhum " Fm. and the Shara Murun Fm.; 3. type section of the Urtyn Obo Fm. Contours are in feet. Modified from Radinsky, 1964b.

the Arshanto Formation than it is to the Irdin Manha Formation, which is characterized by predominantly gray and white sands and gravels. We feel, therefore, that the " Tukhum " Formation can be considered as an equivalent to the Arshanto Formation and a western extension of the same formation. In the Ula Usu region, the base of the " Tukhum " Formation is not visible; the beds are overlain by the late Eocene Shara Murun Formation.

Neither the Sino-Soviet expedition of 1959, nor later work by the IVPP has resulted in recovery of additional fossil mammal material from the " Tukhum " Formation.

Fauna of the " Tukhum " Fm.

CARNIVORA Indet.; cited by Radinsky, 1964b

PERISSODACTYLA

LOPHIALETIDAE — *Lophialetes* cf. *expeditus*? Matthew & Granger, 1925f; cited by Radinsky, 1964b

AMYNODONTIDAE — *Teilhardia*[48] *pretiosa* Matthew et Granger, 1926

" RHINOCEROTOID " Indet.; cited by Radinsky, 1964b

48 Wall and Manning (1986), consider *Teilhardia* not generically distinguishable from *Caenolophus*.

Source : MNHN, Paris

FIG. 55. — Map of the Lantian District, Shaanxi, showing the outcrops of early Tertiary age and their fossil mammal localities. **1**. Eocene Honghe Fm.; **2**. late Eocene to early Oligocene Bailuyuan Fm.; **3**. pre-Tertiary igneous and metamorphic rocks. Modified from Zhang *et al.*, 1978.

Source : MNHN, Paris

Lat. 34° 24′ N
Long. 109° 13′ E
(Lantian Town)

Fig. 2, n° 9

CHINA
SHAANXI PROVINCE
(Shensi)
Lantian District

Honghe Fm. **middle Eocene**

Localities: Sangyuancun and Yinpocun

The history of the discovery of fossil mammals in the Lantian District goes back to the late 1950's when a maxillary of a giant *Crocuta* was sent to the Institute of Geology in Beijing; a team was sent to recover more of the fauna and many Pliocene vertebrates were collected. In the early 1960's an IVPP team discovered in the region, among other things, specimens of Lantian Man. In an effort to expand these discoveries, faunas ranging in age from early Tertiary to Quaternary were found. Field work ended in 1965; all the taxa cited in the accompanying faunal list were collected at that time.

The lower of the two early Tertiary formations in the Lantian district is called the Honghe[49] Formation and is mainly composed of purplish red mudstone and sandy mudstone intercalated with fine sandstone; there are basal gravels. The thickness of the formation is 200 m; it overlies pre-Sinian rocks and is overlain by the Bailuyuan Formation.

There are two localities in the Honghe Formation: Sangyuancun[50], in Lintong County (loc. 65103), about 20 m above the bottom gravel, in purplish red sandy mudstone where *Breviodon* sp. was found. The other locality is at Yinpocun,

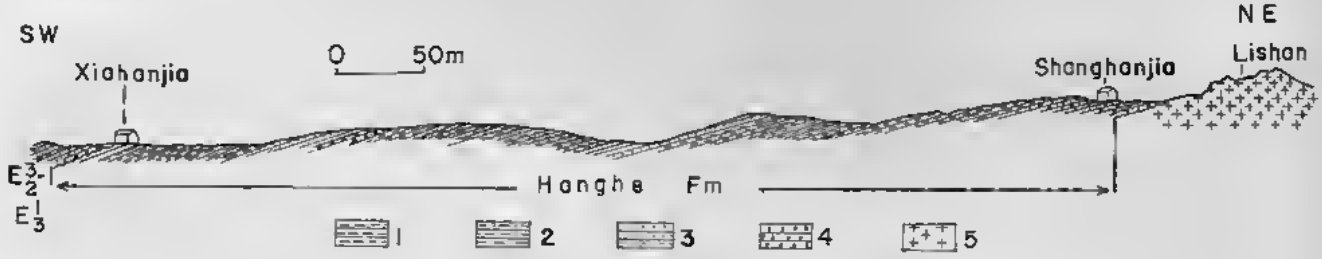


FIG. 56. — Cross section taken in the region of Zhijiagou, Lantian District, Shaanxi, showing the Honghe Fm. **1**. mudstone; **2** sandy mudstone; **3**. sandstone; **4**. conglomerate; **5**. pre-Tertiary rock. Modified from Chia *et al.*, 1966.

near Xian (loc. 65009); the fossils (*Arctotitan honghoensis* and cf. *Deperetella* sp.) were found in a sandstone contained in purplish red mudstone. This sandstone is 9 m thick; the fossil level is 60 m below the top of the formation.

In correlating the Honghe Formation one has relied on the dental morphology of *Arctotitan*; it is larger than any Eocene brontothere either in Asia or in North America, but it is more primitive in structure than all known Oligocene forms. Dentally, it is about at the same evolutionary stage as the middle Eocene *Protitan* and more primitive than the late Eocene *Rhinotitan*. The genus *Breviodon* is also indicative of a middle Eocene age.

49 Honghe = red river.
50 Sangyuancan = mulberry garden village.

Source : MNHN, Paris

Fauna of the Honghe Fm.

PERISSODACTYLA
- BRONTOTHERIIDAE — *Arctotitan honghoensis* Wang, 1978b
- DEPERETELLIDAE — cf. *Deperetella* sp.; cited by Wang, 1978b
- LOPHIALETIDAE — *Breviodon* sp.; cited by Wang, 1978b (= *Breviodon minutus*?; cited by Chow 1978, list on p. 101).

Lat. 35° 54′ N
Long. 117° 44′ E
(Xintai City)

Fig. 2, n° 31

CHINA
SHANDONG PROVINCE
(Shantung)
Xintai District

Guanzhuang Fm. **middle Eocene**

Localities: Guanzhuang, Hsi-Kou, T'an's Lokal

The fossiliferous middle Eocene beds of the Guanzhuang[51] Formation crop out irregularly but rather widely in the Xintai[52] Basin. The latter extends for about 20 km NW-SE, occupying parts of the counties of Menyin, Laiwu, Feixian and Taian, as well as that of Xintai.

This formation, formerly known as the Guanzhuang Series or Guanzhuang Group, is composed of red sand, clay and conglomerate, containing yellow gray sandstone, marl and limestone, with some dark gray carbonaceous shale. It rests disconformably upon the Cretaceous Mengyin Series. Mammalian fossils were discovered mainly in the marl and limestone beds of this formation. In the Mengyin Valley the Guanzhuang Formation can be divided lithologically into three parts. Coarse-grained red sandstone (or sands) and conglomerate play the most important role in the composition of its lower and upper parts; the middle part is made up of red sands, yellow, gray and greenish sandstone, grayish clay, dark gray shale, greenish gray marl and grayish limestone. The total thickness of the Guanzhuang Formation varies from 600 m to 1100 m in the same valley.

The stratigraphy of the Guanzhuang Formation has been discussed by T'an (1923), Andersson (1923), Zdansky (1930), Young (1934), and more recently by Chow (1957b, 1963a), Chow & Tung (1962) and Li (1962). The fossil localities are inaccessible now as a dam was built about 1960 that caused them to be submerged; no further exploitation is possible.

Most of the collecting in the Xintai Basin was done by T'an in 1922, near a village referred to as Kuan-Chuang (which is perhaps Chang-lu-kuan-chuang, situated 10 km southeast of Xintai City). The chalicothere *Grangeria canina* may have come from a younger horizon. According to Li and Ting (1983), all of the material found by Li and his colleagues in 1960 and 1962 was collected in the small quarry of Xi-Xi-Zhou, 5 km WNW of Xintai City; this is probably the same called Hsi-Kou by T'an.

A middle Eocene age for the Guangzhuang Formation is well established by various elements of its fauna: *Palaeosyops*, *Hyrachyus* and *Helaletes* are also represented in the North American Bridger Formation, and the species of coryphodontid probably belongs to a new genus that

51 Guanzhuang (= Kuanchuan) = government officer village.
52 Xintai (= Sintai = Hsin-T'ai) = new Tai (place name).

Source : MNHN, Paris

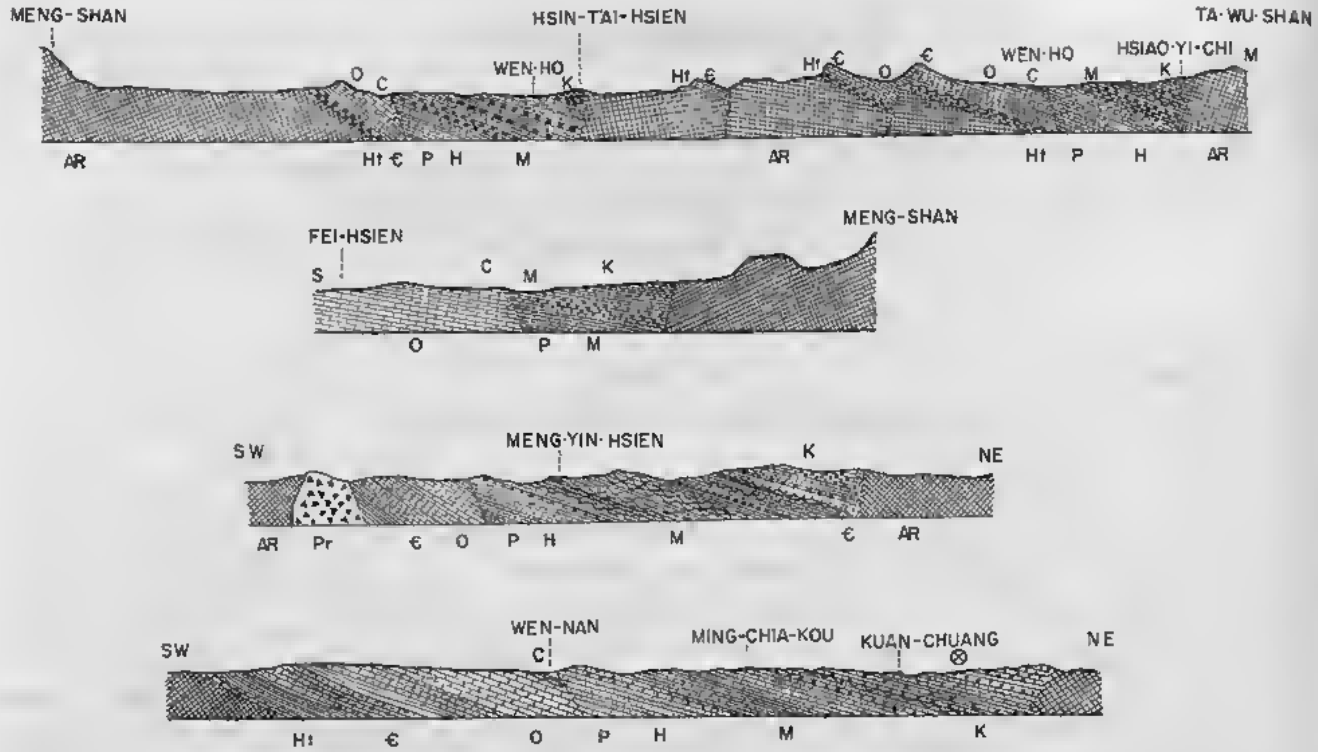


FIG. 57. — Sections showing the distribution of the early Tertiary sediments in Shandong. I. Central Shandong, taken through the Mengyin and Laiwu Valleys; II. Central Shandong, southern part, taken through the Feihsien Valley; III. Cross section taken in the southeastern part of the Mengyin Valley; IV. Cross section taken in the northwestern part of the Mengyin Valley. Most of the fossil mammals that have been collected came from the vicinity of Kuanchuang village. AR, Archaeozoic complex; Ht; Sinian limestone; ε. Cambrian formations; O. Ordovician limestone; C, Palaeozoic coal series; P, quartzose sandstone; H, Hsia-K'un-Lun Series; M, Mengyin Series (Cretaceous); K, Guanzhuang Fm. (middle Eocene); Pr, porphyry. Modified from T'an, 1923.

seems to be intermediate morphologically and phyletically between the Holarctic early Eocene *Coryphodon* and the Asiatic genus *Eudinoceras*. It should be noted that *Hyrachyus* appears earlier in Europe, being found in the Cuisian early Eocene along with *Propalaeotherium*; both, however, are characteristic of Lutetian faunas.

Fauna of the Guanzhuang Fm.

PANTODONTA

CORYPHODONTIDAE
- — "*Coryphodon*" *flerowi* Chow, 1957b, V.P. (4) Lucas, 1982 (= *Manteodon flerowi* Chow, 1957b, *in* Xu, Y., 1976, V.P. (3))
- — Coryphodontidae indet. (opinion of the authors) (= cf. *Uintatherium* sp., cited by Chow & Tung, 1962, V.P. (4); referred to *Gobiatherium* sp. by Tong & Lucas, 1982, but reassigned to cf. *Uintatherium* sp. by Schoch & Lucas, 1985)
- — *Eudinoceras xintaiensis* (Zhou & Qi, 1982) Lucas, 1982 (= *Metacoryphodon xintaiensis* Zhou & Qi, 1982, V.P. (4))

TILLODONTIA

TILLOTHERIIDAE
- — *Kuanchuanius shantunensis* Chow, 1963, V.P. (2)

DINOCERATA

UINTATHERIIDAE Indet.; cited by Tong & Wang, 1981, V.P. (3) (= *Grangeria canina*? sp.; cited by Young & Bien, 1935)

Source : MNHN, Paris

RODENTIA
FAMILY Indet. — Incisor cited by Zdansky, 1930

CREODONTA
HYAENODONTIDAE — *Thinocyon? sichowensis* Chow, 1975, V.P. (3)
(= *Pterodon*? sp.; cited by Young, 1935)

CONDYLARTHRA
FAMILY Indet. — *Haplomylus*? sp.; cited by Zdansky, 1930

PERISSODACTYLA
BRONTOTHERIIDAE — *Palaeosyops* sp.; cited by Chow & Zhai, 1981, MS
(= Brontotheriidae indet.; cited by Zhou & Qi, 1982, V.P. (4))

EQUIDAE — *Propalaeotherium sinense* Zdansky, 1930
— *Propalaeotherium* sp.; cited by Zhou & Qi, 1982, V.P. (4)
(= *Palaeotherium* sp.; cited by Chow, 1963, V.P. (2)

EOMOROPIDAE — *Grangeria canina* Zdansky, 1930

DEPERETELLIDAE — *Teleolophus? shandongensis* Zhou & Qi, 1982, V.P. (4)
— *Teleolophus* sp.; cited by Zhou & Qi, 1982, V.P. (4)

HELALETIDAE — *Hyrachyus modestus*? (Leidy, 1870); cited by Zhou & Qi, 1982, V.P. (4)
— *Hyrachyus metalophus* Zhou & Qi, 1982, V.P. (4)
— *Hyrachyus* sp.; cited by Chow, 1963, V.P. (2) and by Zhou & Qi, 1982, V.P. (4)
— *Helaletes* sp.; cited by Zhou & Qi, 1982, V.P. (4)

LOPHIALETIDAE — *Lophialetes* sp.; cited by Zhou & Qi, 1982, V.P. (4)
— *Schlosseria* sp.; cited by Zhou & Qi, 1982, V.P. (4)
— *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975; cited by Zhou & Qi, 1982, V.P. (4)
(= *Lophialetes minutus* Matthew & Granger, 1925f)
(= *Breviodon? minutus* (Matthew & Granger, 1925f) Radinsky, 1965)

LOPHIALETIDAE? — *Rhodopagus zdanskyi* Lucas & Schoch, 1981
(= Hyracodontidae gen. & sp. indet.; cited by Zdansky, 1930)
(= *Rhodopagus*? sp.; cited by Radinsky, 1965)
— *Rhodopagus laiwuensis* Qi & Meng, 1983, V.P. (2)

ORDER Indet.
FAMILY Indet. — *Heptaconodon dubium* Zdansky, 1930

Lat. 26° 48′ N
Long. 100° 16′ E
(Lijiang City)

Fig. 2, n° 32

CHINA
YUNNAN PROVINCE
Lijiang Basin

Xiangshan Fm. **middle Eocene**

In the 1960's, Mr. Chao Kuo-kuang, a geologist, discovered Eocene mammalian fossils in the early Tertiary deposits of this basin, which he called the Lijiang Formation. Inspired by the find, an IVPP crew went to work in the area in 1972.

Source : MNHN, Paris

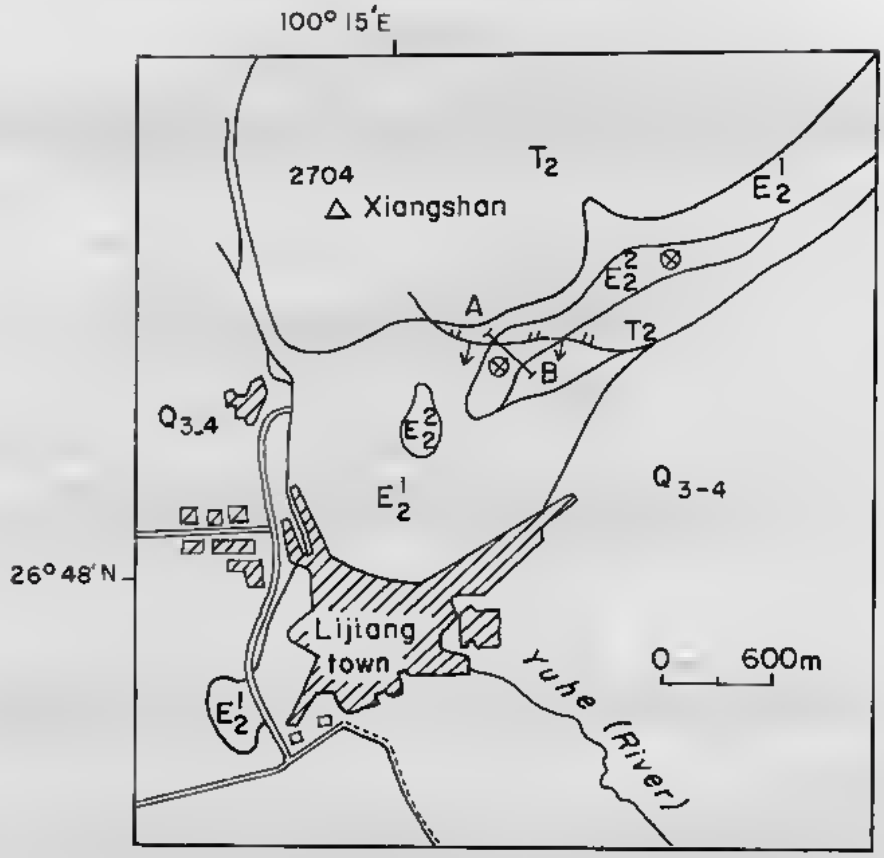


FIG. 58. — Geological sketch map of the Xiangshan District, Lijiang Basin, Yunnan. T_2: Triassic limestone; E_2^1: Lijiang Formation (restricted); E_2^2: Kiangshan Formation; Q_{3-4}: late Quaternary to Recent. From a map provided by Zong G.-f.

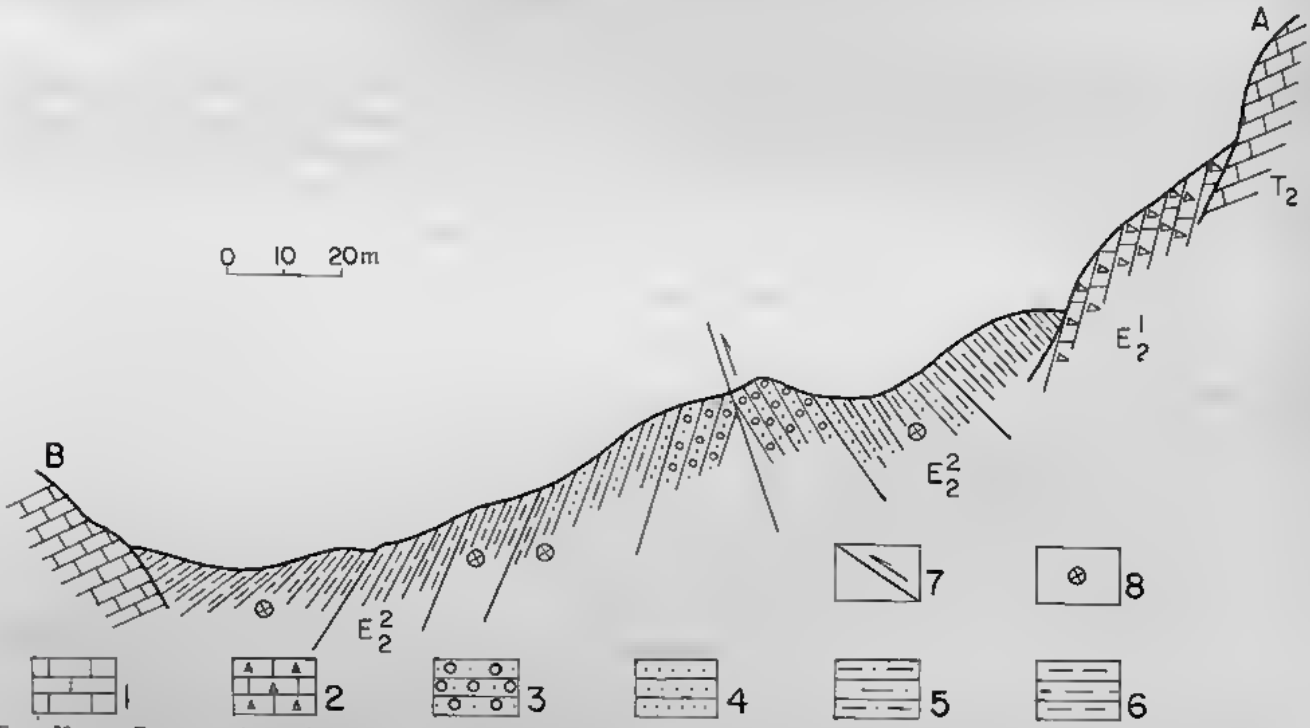


FIG. 59. — Cross section taken through the south slope of Xiangshan (mountain). Lijiang Basin, Yunnan. **1**. Triassic limestone; **2** breccia; **3**. conglomeratic sand; **4** sandstone; **5**. sandy mudstone; **6** mudstone; **7**. fault; **8**. fossil mammal locality. From a figure provided by Zong G.-f.

Source : MNHN, Paris

The originally designated Lijiang [53] Formation may be divided into two parts. The upper part is now called the Xiangshan [54] Formation and is mainly composed of brick red sand, sandy clay and gray-white clay which appear to be of lacustrine origin. Its thickness varies from 150 to 200 m and it disconformably overlies the restricted Lijiang Formation. The latter, which forms the lower part of the sequence, consists of thick gravel deposits. No fossils are known from it and its thickness was not given. It is underlain by Triassic sediments and overlain by the Neogene Shuanghe Coal Formation in this district.

The fauna of the Xiangshan Formation is incompletely described and its analysis presents difficulty. *Honanodon hebetis, Eomoropus, Deperetella, Caenolophus, Amynodon* and *Prohyracodon* are found in both Irdin Manha and Shara Murun equivalents. *Breviodon* and *Schlosseria* are, so far however, unknown in Shara Murun correlatives, but the anthracotheres, *Anthracokeryx* and *Anthracothema* are, so far, restricted to the latter. In view of the southern situation of the Lijiang Basin and the seeming preference of Asian anthracotheres for southern climates, we would tend to regard them as early occurrences in a fauna that is otherwise slightly more like that of the Irdin Manha equivalents than it is of the Shara Murun. We consider the fauna as perhaps late in the middle Eocene.

Fauna of the Xiangshan Formation

CREODONTA

HYAENODONTIDAE Indet.; cited by Zhang *et al.*, 1978

CREODONTA Indet.; cited by Zhang *et al.*, 1978

CONDYLARTHRA

MESONYCHIDAE — *Honanodon hebetis* Chow, 1965, V.P. (3); cited by Zhang *et al.*, 1978
— *Honanodon* sp.; cited by Zhang *et al.*, 1978

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Zhang *et al.*, 1978

CHALICOTHERIIDAE? — *Lunania* cf. *youngi* Chow, 1957a, V.P. (3); cited by Zhang *et al.*, 1978

EOMOROPIDAE — *Eomoropus* sp.; cited by Zhang *et al.*, 1978

DEPERETELLIDAE — *Deperetella* sp.; cited by Zhang *et al.*, 1978
— *Teleolophus* sp.; cited by Zhang *et al.*, 1978

LOPHIALETIDAE — *Breviodon* n. sp.; cited by Zhang *et al.*, 1978
— *Schlosseria* sp.; cited by Zhang *et al.*, 1978

LOPHIODONTIDAE — *Lophiodon*? spp.; cited by Zhang *et al.*, 1978 (questioned by the authors)

HYRACODONTIDAE — *Prohyracodon* sp.; cited by Zhang *et al.*, 1978

AMYNODONTIDAE — *Caenolophus* sp.; cited by Zhang *et al.*, 1978
— *Amynodon* sp.; cited by Zhang *et al.*, 1978

ARTIODACTYLA

ENTELODONTIDAE — *Eoentelodon* n. sp.; cited by Zhang *et al.*, 1978, as *E. likiangensis* (*nomen nudum*)

ANTHRACOTHERIIDAE — *Anthracokeryx* sp.; cited by Zhang *et al.*, 1978
— *Anthracothema* sp.; cited by Zhang *et al.*, 1978

LEPTOMERYCIDAE? Indet., cited by Zhang *et al.*, 1978 (as Hypertragulidae Indet.)

53 Lijiang = beautiful big river (city name).
54 Xiangshan = elephant hill.

Source : MNHN, Paris

Lat. 24° 47′ N
Long. 103° 16′ E
(Lunan Town))

Fig. 2, n° 25

CHINA

YUNNAN PROVINCE

Lunan Basin

Lumeiyi Fm. **middle-late Eocene**

The fossil beds of Lunan [55] in eastern Yunnan were first studied on the basis of material collected by M.-n. Bien before 1940. Many publications followed, but stratigraphically many of the conclusions and propositions made before 1978 have now been questioned (see article by Zheng *et al.*, 1978). The early Tertiary rocks were first divided into an upper formation, the Anrencun Formation, and a lower one, the Lunan Formation. The former was considered to be Oligocene and the latter to be late Eocene. Later work suggested that the Anrencun Formation extended into the late Eocene, but these suppositions were based principally on the stage of evolution of the taxa being studied; little stratigraphical control was possible because many of the specimens were purchased from peasants who were actively exploiting the fossil beds for material to be sold and used in medicines, and who did not always correctly explain where they came from.

During a new analysis of the fauna, based on the collections made by an IVPP expedition to the region in 1970, the previous results, and the specimens upon which they were based, were put aside and the beds were divided according to the fossils actually found in place. This resulted in the abandonment of the name Anrencun, and the establishment of the Lunan Group containing the newly named (Zheng *et al.*, 1978) Xiaotun Formation, representing the Oligocene part of the series and the Lumeiyi Formation, representing the middle-late Eocene part.

The Lumeiyi [56] Formation is mainly sandy clays and red, argillaceous sandstone; in its upper part it contains thick beds of white or gray-white marls. Many fossils occur in the marls, although they are also found in the sandstone and the sandy clay. Its thickness is 752 m and it overlies a Paleozoic limestone.

In the faunal list published by Zheng *et al.*, (1978, p. 28), all the taxa have either been found in place or are located stratigraphically with certainty. The presence of an asterisk after a name indicates that the species is to be described; a double asterisk is a new genus to be described. In the text (p. 27), the sign # means that the taxon was not collected by the IVPP team but was cited in previous papers and is thought to be correctly situated stratigraphically.

Analysis of the faunal list of taxa considered to be of undoubted Eocene age (in opposition to those from the overlying Oligocene Xiaotun Fm. that had sometimes been mixed) permits the following remarks. First of all, 3 species occur in common with the Shara Murun assemblage or equivalents (*Diplolophodon similis, Eomoropus quadridentatus* and *Chailicyon crassidens*) and 2 genera are typical of the latter (*Rhinotitan* and *Pterodon*). A certain number are common to both the Irdin Manha and Shara Murun faunal groups (*Honanodon, Litolophus, Amynodon, Deperetella, Caenolophus*, cf. *Paramynodon*), and others are known in neither (*Dianotitan, Indricotherium, Probrachyodus* and *Paracadurcodon*?). This still leaves, however, the bulk of the Lumeiyi fauna as indicative of the Irdin Manha faunal group: *Protitan* cf. *robustus, Helaletes mongoliensis, Teleolophus* cf. *medius, Lophialetes expeditus, Breviodon* (2 spp.), *Prohyracodon* (3 spp.), *Teilhardia, Ilianodon, Gobiohyus, Eoentelodon, Forstercooperia*, and Tillotheriidae. No conclusion as to the precise age of the Lumeiyi Fm. is possible based on such a faunal mixture.

55 Lunan = (lu = road; nan = south); south of the road.
56 Lumeiyi = (lu = road; mei = beautiful; yi = place) a village name whose meaning is not clear.

Source : MNHN, Paris

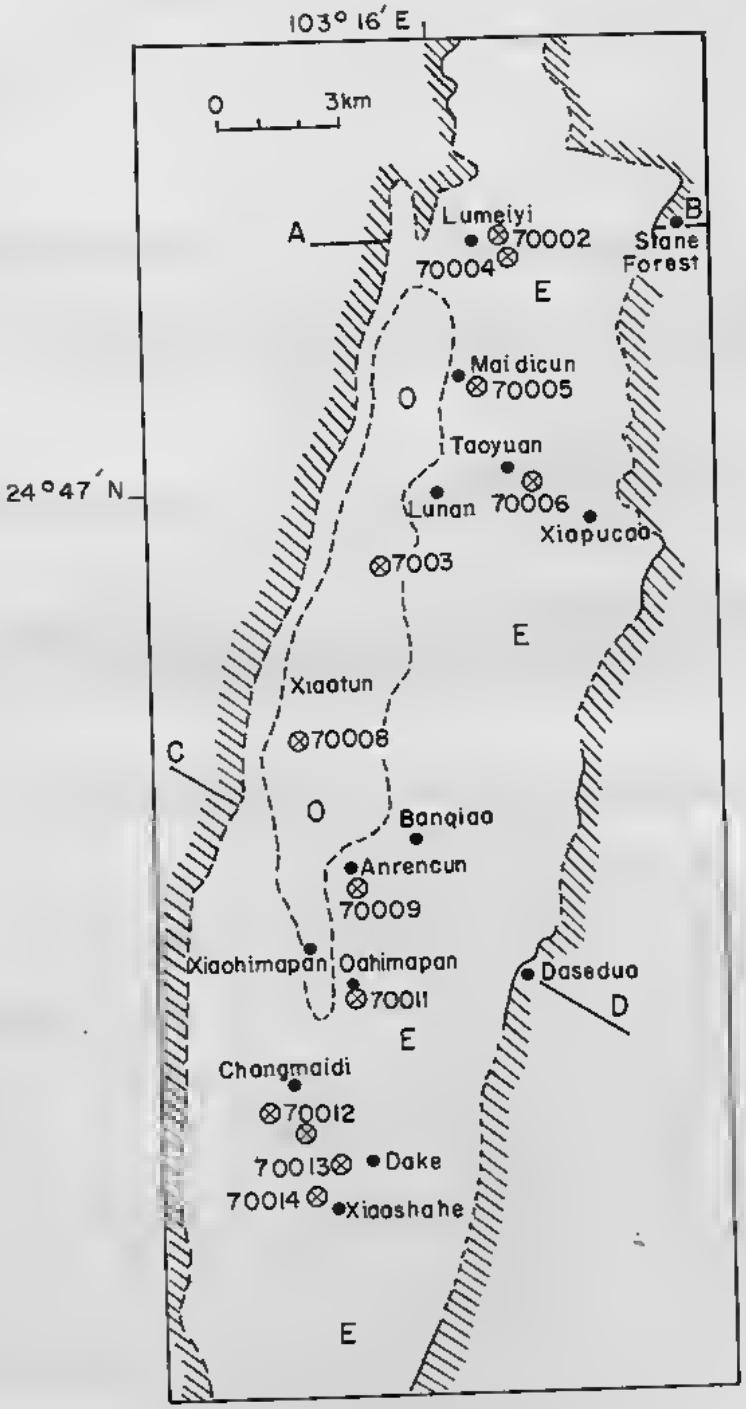


FIG. 60. — Outcrop map of the Lunan Basin, Yunnan. E: Eocene sediments of the Lumeiyi Fm.; O: Oligocene Xiaotun Fm. The Tertiary formations are surrounded by Paleozoic rock. A-B and C-D indicate cross sections. Modified from Zheng *et al.*, 1978.

Source : MNHN, Paris

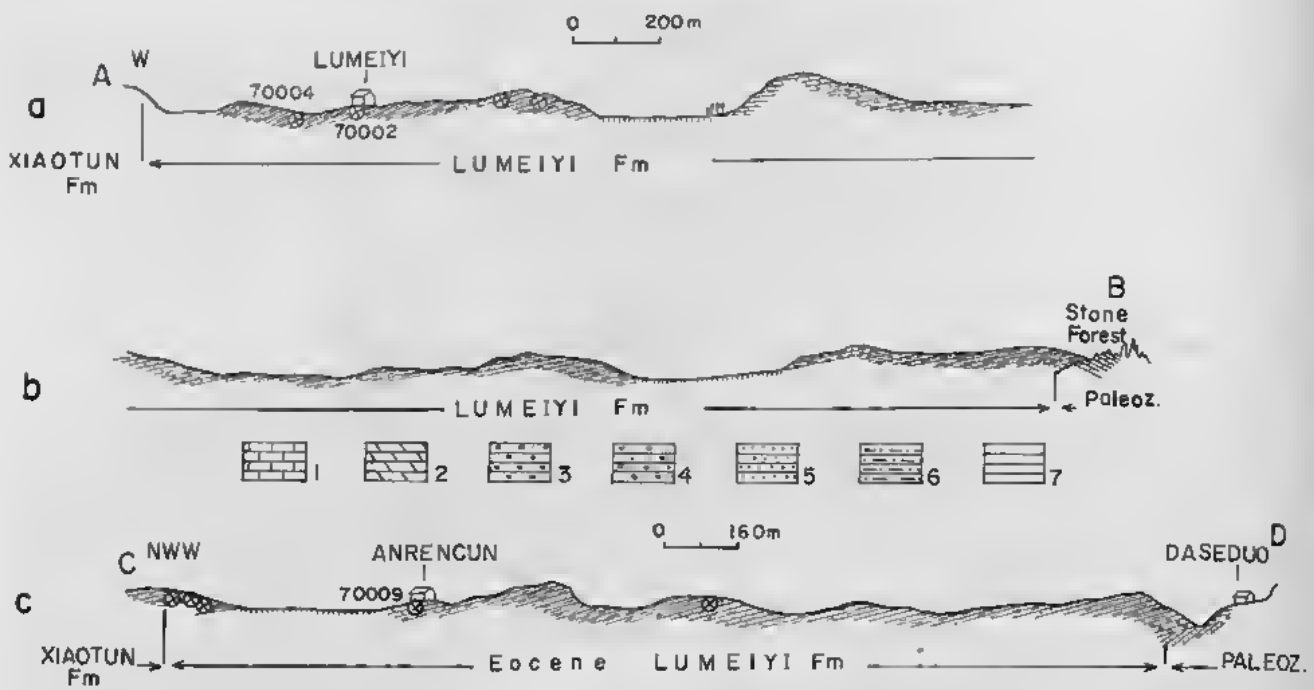


FIG. 61. — a and b. Cross section in the Lunan Basin, Yunnan, between Lumeiyi and Stone Forest (A to B on the outcrop map). c. Cross section in the Lunan Basin between Arencun and Daseduo (C to D on the outcrop map). 1. limestone; 2 marl; 3. conglomerate; 4. conglomeratic sandstone; 5. sandstone; 6. mudstone; 7. shale. Modified from Zheng *et al.*, 1978.

Faunal list of taxa whose stratigraphical position in the Lumeiyi Fm. is sure

CONDYLARTHRA

MESONYCHIDAE
— *Honanodon* sp.; cited by Zheng *et al.*, 1978

PERISSODACTYLA

BRONTOTHERIIDAE
— *Dianotitan lunanensis* (Chow & Hu, 1959) Chow *et al.*, 1974, V.P. (4)
(= *Parabrontops lunanensis* Chow & Hu, 1959)
— *Protitan* cf. *robustus* Granger & Gregory, 1943; cited by Zheng *et al.*, 1978
— Brontotheriidae gen et sp. nov.; cited by Zheng *et al.*, 1978

EOMOROPIDAE
— *Litolophus? ulterior* (Chow, 1962) Radinsky, 1964a
(= *Eomoropus ulterior* Chow, 1962, V.P. (3))

CHALICOTHERIIDAE?
— *Lunania youngi* Chow, 1957a, V.P. (3)

DEPERETELLIDAE
— *Diplolophodon similis* Zdansky, 1930; cited by Zheng *et al.*, 1978 (= *Deperetella similis* (Zdansky, 1930) Radinsky, 1965; cited by Chow *et al.*, 1974, V.P. (4)). *Diplolophodon* revalidated by Ding *et al.*, 1977, V.P. (1)

HELALETIDAE
— *Helaletes mongoliensis* (Osborn, 1923a) Radinsky, 1965
(= *Desmatotherium mongoliense* Osborn, 1923a)
— *Teleolophus?* sp.; cited by Zheng *et al.*, 1978
— *Hyrachyus lunanensis* Huang & Qi, 1982, V.P. (4)
— *Hyrachyus minor* Huang & Qi, 1982, V.P. (4)

LOPHIALETIDAE
— *Breviodon sahoensis* Chow *et al.*, 1974, V.P. (4)
— *Breviodon* sp. nov.; cited by Zheng *et al.*, 1978

Source : MNHN, Paris

— *Lophialetes expeditus* Matthew & Granger, 1925f; cited by Zheng *et al.*, 1978
— *Lophialetes* cf. *expeditus* Matthew & Granger, 1925f; cited by Huang & Qi, 1982, V.P. (4)
— *Lophialetes yunnanensis* Huang & Qi, 1982, V.P. (4)
— *Breviodon lumeiyiensis* Huang & Qi, 1982, V.P. (4)

HYRACODONTIDAE
— *Prohyracodon meridionale* Chow & Xu, 1961, V.P. (4)
— *Prohyracodon* cf. *orientale* Koch, 1897; cited by Zheng *et al.*, 1978
— *Ilianodon lunanensis* Chow & Xu, 1961, V.P. (4)
— *Indricotherium parvum* Chow, 1958b, V.P. (4)
— *Indricotherium*? sp.; cited by Zheng *et al.*, 1978

AMYNODONTIDAE
— *Amynodon lunanensis* Chow *et al.*, 1964, V.P. (4)
— *Amynodon* spp.; cited by Zheng *et al.*, 1978
— cf. *Paramynodon* sp.; cited by Xu, 1966, V.P. (2)
— *Telhardia pretiosa* Matthew & Granger, 1926; cited by Zheng *et al.*, 1978
— *Teilhardia*? sp.; cited by Zheng *et al.*, 1978

ARTIODACTYLA

HELOHYIDAE
— *Gobiohyus* sp.; cited by Zheng *et al.*, 1978

ENTELODONTIDAE
— *Eoentelodon yunnanense* Chow, 1958a, V.P. (1)

Faunal list of taxa whose stratigraphical position is uncertain but which are considered to be late Eocene in age and probably from the Lumeiyi Fm.

TILLODONTIA

TILLOTHERIIDAE Indet.: cited by Ding *et al.*, 1977, V.P. (1) as Tillodontidae indet.

CARNIVORA

CANIDAE
— *Chailicyon crassidens* Chow, 1975, V.P. (3)
(= Caninae indet.; cited by Xu & Chiu, 1962, V.P. (4))

FELIDAE Indet.; cited by Zheng *et al.*, 1978

CREODONTA

HYAENODONTIDAE
— *Pterodon dahkoensis* Cbow, 1975, V.P. (3)

PERISSODACTYLA

BRONTOTHERIIDAE
— *Rhinotitan quadridens* Xu & Chiu, 1962, V.P. (4)

EOMOROPIDAE
— *Eomoropus quadridentatus* Zdansky, 1930; cited by Chow *et al.*, 1974, V.P. (4)
(= *Eomoropus*? *quadridentatus* Zdansky, 1930, *in* Radinsky, 1964a)

DEPERETELLIDAE
— *Deperetella dienensis* Chow *et al.*, 1974, V.P. (4)

HELALETIDAE
— *Teleolophus* cf. *medius*[57] Matthew & Granger, 1925f
(= *Teleolophus medius* Matthew & Granger, 1925f; cited by Xu & Chiu, 1962, V.P. (3)

HYRACODONTIDAE
— *Prohyracodon progressa* Chow & Xu, 1961, V.P. (4) (Chow *et al.*, 1974, V.P. (4), p. 272, deny Radinsky's (1967) synonymy of this species with *Prohyracodon meridionale*)
— *Forstercooperia shiwopuensis* Chow *et al.*, 1974, V.P. (4)

AMYNODONTIDAE
— *Amynodon altidens* Xu & Chiu, 1962, V.P. (4)
— *Paracadurcodon*? sp.; cited by Xu, 1966, V.P. (2)

57 Radinsky (1965, p. 220) notes that this form is typically an Irdin Manha equivalent species; its presence in a Shara Murun level would be anomalous.

Source : MNHN, Paris

— *Caenolophus medius* Chow, 1957a, V.P. (3) (may be congeneric with *Hyracodon*, *in* Radinsky, 1967)
— *Caenolophus* sp.; cited by Xu & Chiu, 1962, V.P. (4)

ARTIODACTYLA

ANTHRACOTHERIIDAE

— *Probrachyodus*[58] *panchiaoensis* Xu & Chiu, *in* Xu, 1962, V.P. (3)

Lat. 46° N, approx.
Long. 88° E, approx.

Fig. 2, n° 33

CHINA

XINJIANG UYGUR AUTONOMOUS REGION

(Sinkiang)

Junggar Basin

Honglishan? or Wulungu? Fm. **middle Eocene**

Locality: Xiyiliang Region

In 1955 the 631st Geological Brigade found, in the northwestern part of the Junggar[59] Basin, a premolar of *Eudinoceras*. This specimen was described by Chow & Hu (1956) and cited by Chow (1960). Unfortunately, the exact locality data of the find were not known with certainty (published reports are apparently in error); Xiyiliang[60] is the name of a large area; it was formerly referred to as Luliang.

The stratigraphic sequence in this region consists of the red, coarse-grained detritals of the late Cretaceous Alikhu[61] Fm.; the bottom of the formation is not visible, but 63 m have been measured. An unconformity separates it from the Paleocene - Eocene Honglishan[62] Fm., composed of 75 m of red mudstone with grayish

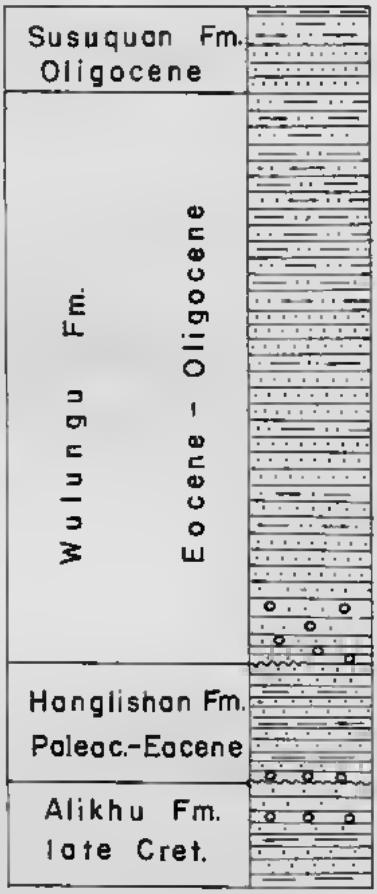


FIG. 62. — Stratigraphic section taken in the Xiyiliang area, Junggar Basin, Xinjiang. Susuquan Fm.: red sandstone and sandy mudstones; thickness varies greatly. Wulungu Fm.: grayish green thick sandy mudstone and sandstone, with occasional red mudstone bells; 350 m. *Lophialetes* cf. *expeditus* might occur here. Honglishan Fm.: red mudstone with grayish green mudstone and basal gravels; 75 m. *Eudinoceras* sp. was perhaps found here. Alikhu Fm.; red coarse-grained detritals; 63 m. Bottom not visible. Modified from data provided by Peng Xi-ling, 1981.

58 According to Dineur (1982), this genus is perhaps inseparable from *Anthracokerys*.
59 Junggar = Dzungaria.
60 Xiyiliang = lizard ridge.
61 Alikhu = Alik Lake.
62 Honglishan = red gravel hill.

Source : MNHN, Paris

green mudstone and a basal bed of gravel. The overlying Wulungu [63] Fm. (Eocene to Oligocene) is in places separated by an unconformity. It consists of 350 m of grayish green thick sandy mudstone and sandstone with occasional red mudstone belts. The series is capped by the red sandstone and sandy mudstone of the Oligocene Susuquan [64] Fm.; it varies greatly in thickness.

It is possible that the *Eudinoceras* specimen comes from the Honglishan Formation, which is the lower level, or it could have come from the overlying Wulungu Formation. According to geologists the *Eudinoceras* and *Lophialetes* specimens should be from two different formations, but both fossils are found in the Irdin Manha fauna and could come from a single formation, which one cannot be said. Both, however, are from the Xiyiliang region. Li & Ting (1983) list *Eudinoceras* as from the Honglishan Formation and *Lophialetes* (in addition to an unidentified felid) as from the Wulungu Formation. These fossils are important in that they signal the presence of Eocene fossiliferous beds in the Xiyiliang region and that further investigation of the area is merited.

Fauna of the Honglishan or the Wulungu Fm.

PANTODONTA
- CORYPHODONTIDAE — *Eudinoceras* sp.; cited by Chow 1960, V.P. (2)

CARNIVORA
- FELIDAE Indet.; cited by Chow, 1958, V.P. (4)

PERISSODACTYLA
- LOPHIALETIDAE — *Lophialetes expeditus* Matthew & Granger 1925f; cited by Chow, 1960, V.P. (2)
  (= *Lophialetes* cf. *expeditus*; cited by Chow, 1958c, V.P. (4))
  (Radinsky, 1965, says it is either *Lophialetes* or *Schlosseria*)

Lat. 42° 30′ - 43° 30′ N
Long. 88° 00′ - 92° 00′ E

Fig. 2, n° 1

CHINA
XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)
Turpan Basin

Liankan Fm. **middle or late Eocene**

Localities: Liankan and Lianmuqin Passes

For information on the Turpan Basin, the reader is referred to the descriptions concerning the late Paleocene Taizicun, and the early Eocene Dabu and the Shisanjianfang Formations. The localities of the Liankan [65] Formation in which fossil mammals have been found, Lianmuqin Pass (66014) and Liankan (66020), are in the Huoyanshan Mountains. At the Lianmuqin Pass section, the Liankan Formation can be divided into 9 levels, extending through 82 m of sediment; it is mostly composed of multicolored sandstone and clays. Fossils were found in both

63 Wulungu = river name.
64 Susuquan = Susu Spring.
65 Lian = name of a well connecting with the underground water (canal) system, called the kan.

Source : MNHN, Paris

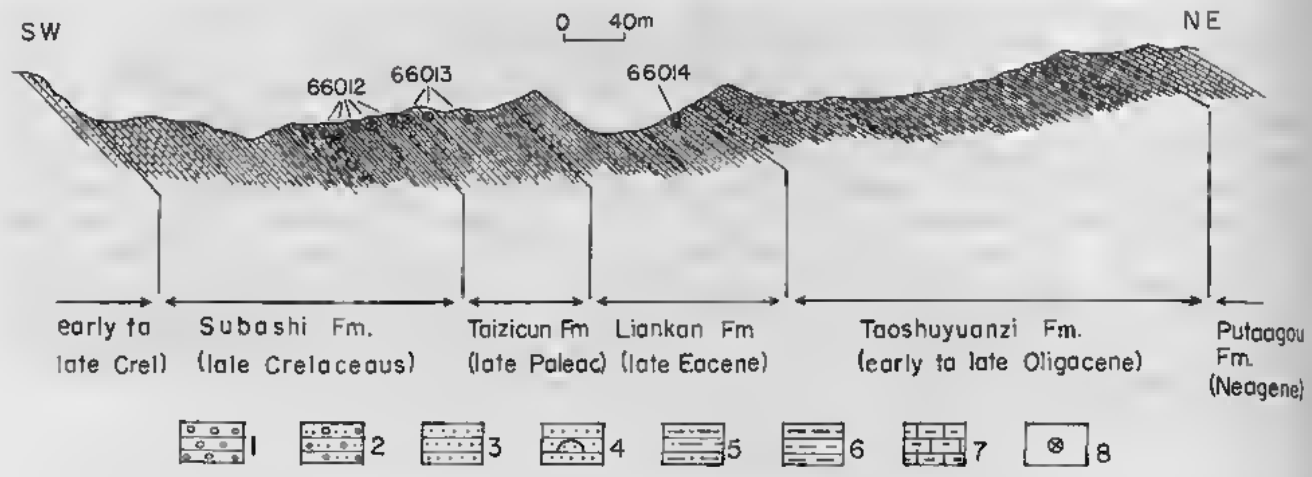


FIG. 63. — Cross section taken at Lianmuqin Pass, Huoyanshan (Mountains), central part of the Turpan Basin, Xinjiang. 1, conglomerate; 2, gravelly sandstone; 3, sandstone; 4, sandstone with lens; 5, sandy mudstone; 6, mudstone; 7, marl; 8, fossil mammal locality. Modified from Zhai *et al.*, 1978

the upper and the lower part of the formation. It overlies disconformably the early Eocene Taizicun Formation and is overlain itself by the early to late Oligocene Taoshuyuanzi Formation.

Examination of the fauna reveals characters that are indecisive: *Teleolophus*, *Lophialetes*, and the Lophialetidae in general, are typical representatives of the Irdin Manha group of faunas. *Sharamynodon* was described from Shara Murun, but Wall (pers, com., 1981) doubts that it is generically separable from *Lushiamynodon*, a form more characteristic of the Irdin Manha faunas. *Rhinotitan* is, of course, a Shara Murun genus, but its identity here is questioned, as is that of *Bothriodon*. *Amynodon* is found in both and tends to indicate a late age. Given the preponderance of lophialetids (4 species are listed) it would appear that at least part of the Liankan Fm. is referable to the middle Eocene. A biostratigraphic analysis should be made in order to explore the possibility of there being two age levels within the Liankan Fm. For the moment we do not feel that a decision is possible; the faunal list below will not be included in our composite lists, pending resolution of the age of this formation.

Fauna of the Liankan Fm.

PERISSODACTYLA

BRONTOTHERIIDAE — *Rhinotitan*? sp.; cited by Zheng, 1978

DEPERETELLIDAE — *Teleolophus liankanensis* Zheng, 1978

LOPHIALETIDAE — *Lophialetes expeditus* Matthew & Granger 1925f; cited by Zheng, 1978

— Lophialetidae indet., 3 spp.; cited by Zheng, 1978

AMYNODONTIDAE — *Sharamynodon mongoliensis* (Osborn, 1936) Kretzoi, 1942 (= *Amynodon mongoliensis* Osborn, 1936)

— *Amynodon* sp.; cited by Zheng, 1978

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Bothriodon*? sp.[66]; cited by Zheng, 1978

LEPTOMERYCIDAE — *Xinjiangmeryx parvus* Zheng, 1978

66 The presence of *Bothriodon* in the late Eocene is doubtful; the identification is based on a partial lower molar.

Source : MNHN, Paris

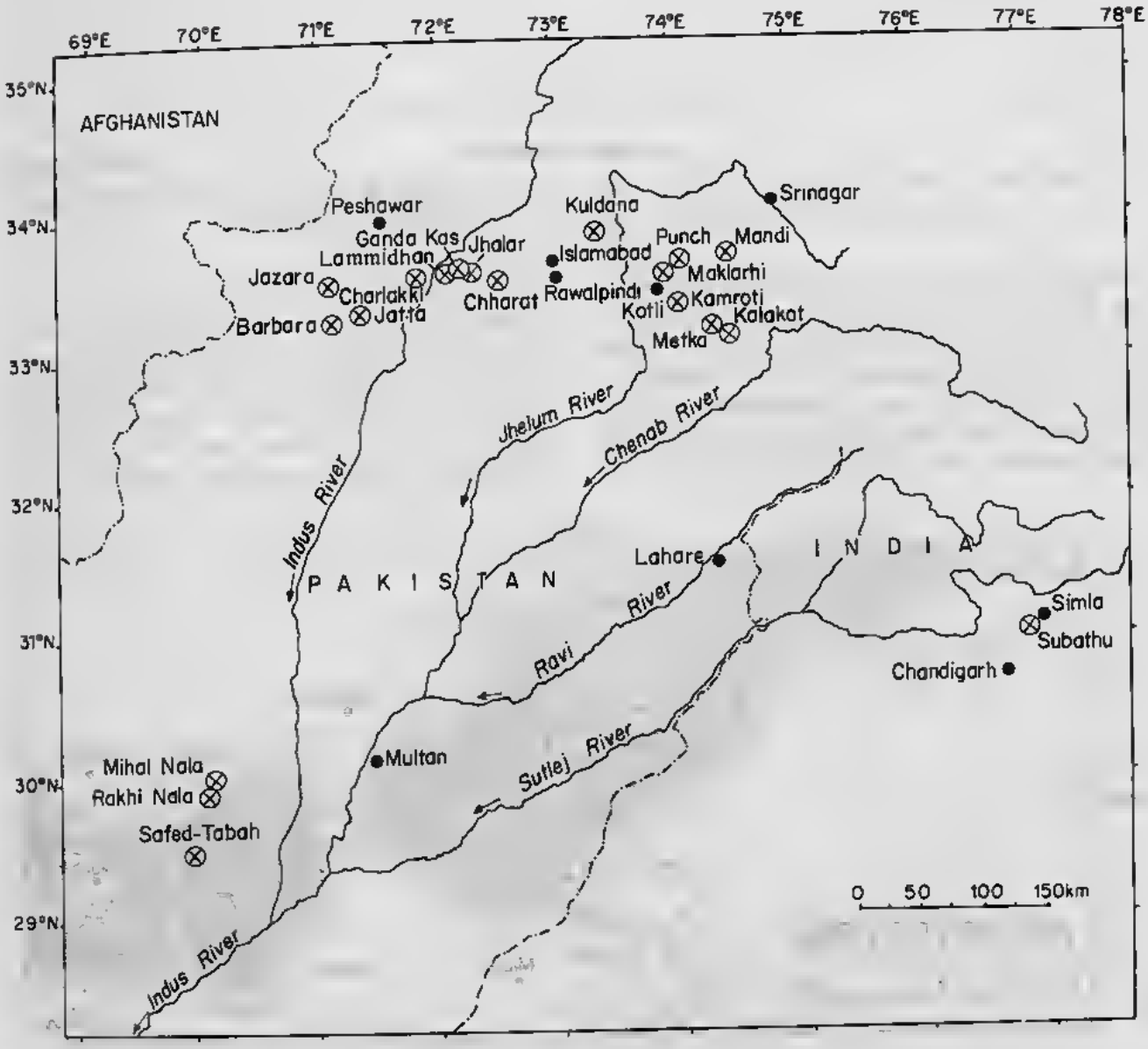


FIG. 64. — Eocene fossil mammal localities of the Indian Subcontinent: in the Domanda Formation of the lower Indus Basin, in the Kuldana Formation of northern Pakistan (from Barbora and Jozara to Kuldana), and in the Subathu Formation of northwestern India (from Punch and Kamroti to Subathu). Modified from Gingerich & Russell, 1981, and Hartenberger, 1982.

Source : MNHN, Paris

Lat. 33° 13′ 30″ N
Long. 74° 25′ E
(Kalakot village)

INDIA

JAMMU AND KASHMIR STATE

Subathu Formation **middle Eocene**

Localities: Rajauri District; Kalakot, Jigni, Sind, Moghla, Metka, Beragoa and Balli; Punch District Mandi; Himachal Pradesh State, Solan District, Simla Hills; Subathu

Fossil vertebrates were discovered in 1970, 6 km WNW of Kalakot[67], near the Kalakot-Rajauri road, by a member of the Indian Oil and Natural Gas Commission (ONGC). Teams from the Lucknow University immediately followed suite and a fairly well diversified fauna has been made known from the region.

The vertebrates come from a 4.5-7 m thick red (or mauve) colored, marly claystone, with a concentration of material in a level from about 5 to 30 cm in thickness. The bed extends laterally for several kilometers and is traceable in all the inliers between Kalakot and Riasi. In fact, mammalian fossils have been obtained from

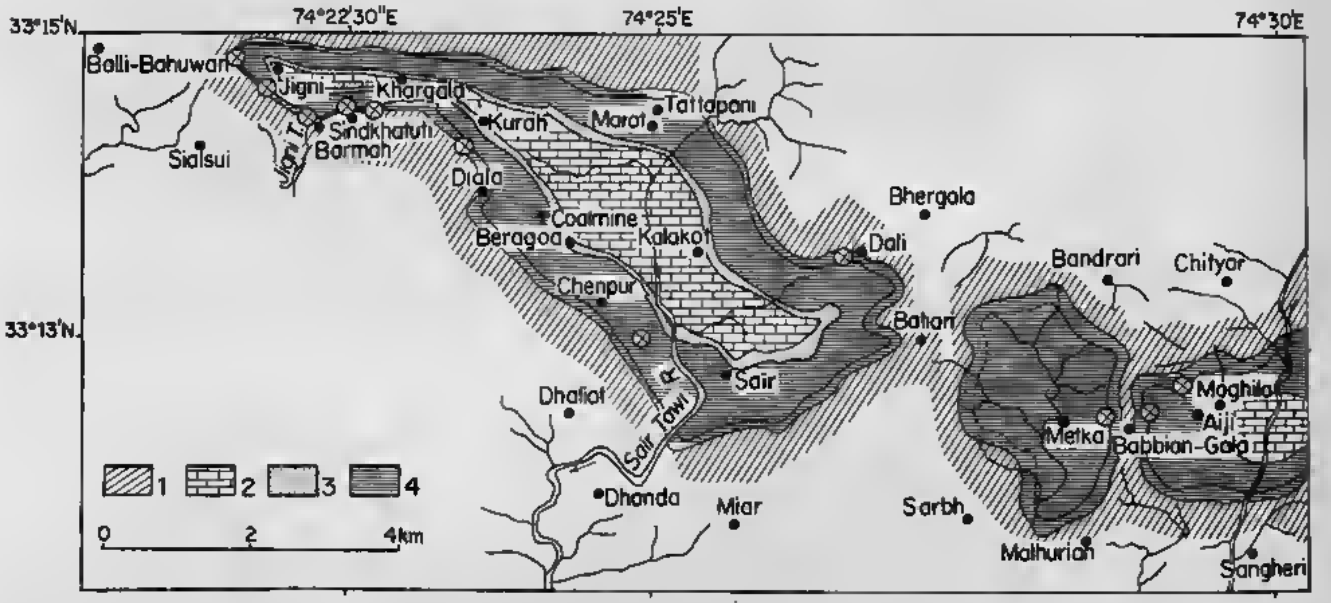


FIG. 65. — Map of the Kalakot, Metka and Moghla areas, Rajauri District, Jammu and Kashmir State, India, showing the position of the various localities in the upper Subathu Fm. that furnished fossil mammals. The narrow band of outcropping upper Subathu is distinguished on the map from the combined middle and lower Subathu. The two sites at the northwest extension of the outcrops are referred to as the Jigni localities; that situated immediately to the north of Sindkhatuli as well as the one to the east of the village are termed the Sindkhatuli localities. Fossils have been found from south of Diala to as far north as the sharp bend to the west in the outcrops. The locality about midway between Chenpur and Sair is referred to as Sair West. At the approximate borders of the Metka and Moghila inliers are two localities known as West Babbian Gala and East Babbian Gala; the easternmost site is called Moghla West. 1. lower Murree Fm.; 2. Sirban limestone; 3. cherl breccia; 4. Subathu Fm., with the outcrop of the upper fossiliferous part indicated. Modified from Kumar & Sahni, 1985.

67 Kalakot = black fort.

Source : MNHN, Paris

extensions of this bed as far west as Mandi in Punch [68] and as far east as the town of Subathu (Ranga Rao & Misra, 1983) in the Simla Hills. The main collecting areas in the Kalakot region (the most productive) have been near the village of Sind for field crews from the Oil and Natural Gas Commission; for the Lucknow University parties (and more recently, those from the Panjab University, Chandigarh) collecting has centered around Jigni [69], where two fossiliferous bands have been observed. The vicinity of Metka has also produced several localities (in the Metka inlier) and 2 to 3 fossil producing levels appear to occur a meter or two apart. The Moghla [70] inlier is also fossiliferous, as are sites at Beraogoa [71] and Balli.

Outcrops of the Subathu Formation are found in three structural belts in the Jammu Hills;

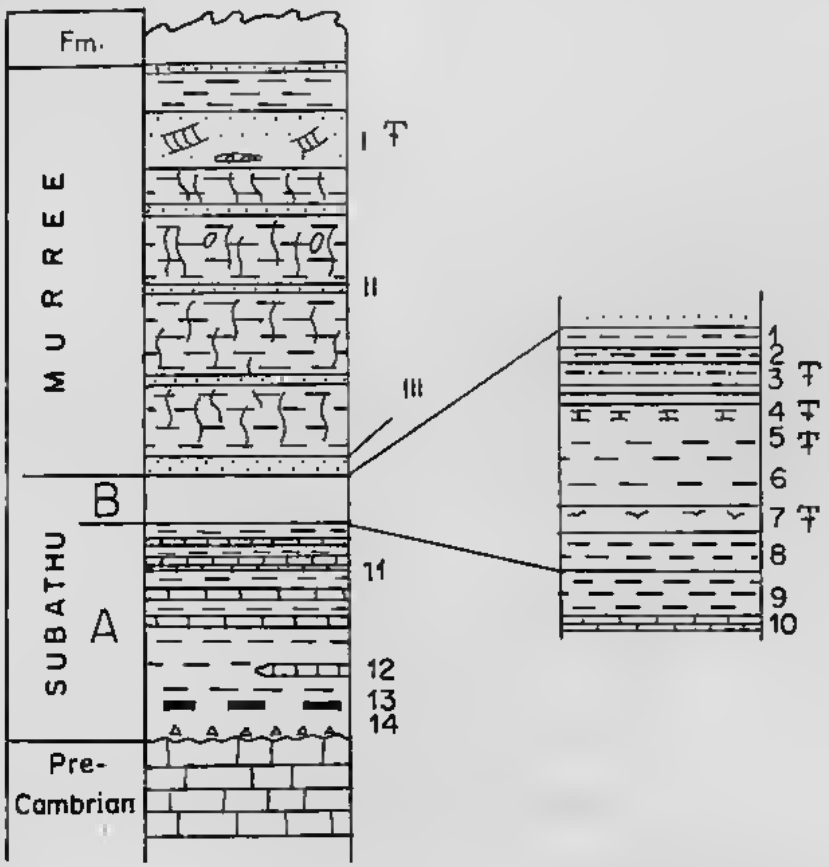


FIG. 66. — Lithostratigraphy of the Subathu Formation in the Kalakot area, India. Beds I in the overlying Murree Formation are thick, greenish gray micaceous sandstone with current bedding and ripplemarks; several layers of bone-bearing clay conglomerate are present and fossil plants are known. Beds II are an alternation of brick red clays, red siltstones, clay conglomerates, red silty sandstone and clays with several layers of bioturbation, worm tracks and layers of caliche. Bed III is the greenish gray sandstone that forms the base of the Murree Fm. Precise age determination of the Murree Fm. awaits study of its vertebrate fossils.

The thickness of Subathu unit A is approximately 117 m; unit B is approximately 13 m. Unit B is considered contemporaneous with the Kuldana Fm. in Pakistan. It consists of the following: **1**. purple clay; **2**. bluish gray clay; **3**. massive bluish gray clay, rich in bone near its base; **4**. argillaceous, massive, bluish gray limestone; contains the main bone-bearing bed; **5**. blue, purple, massive shale; bone-bearing; **6**. alternations of purple, indigo blue, massive clays; **7**. bluish gray siltstone, richly fossiliferous in places; **8**. red clay; **9**. green shale; **10**. foraminiferal shale. Unit A consists of the following; **11**. alternations of creamy white foraminiferal limestone and greenish gray shales; **12**. olive green shales with oyster marls and foraminiferal shales; **13**. coaly shales and coal beds; **14**. breccia or conglomerate. Modified from Ranga Rao (in press).

68 Punch (= Poonch) = five.
69 Jigni (= Jigini).
70 Moghla (= Mahogala = Moghila).
71 Beragoa (= Beraguoa = Bergoa).

Source : MNHN, Paris

although dating by Foraminifera gives nearly the same age to all (late Paleocene to the early part of the middle Eocene), these exposures show considerable change of facies from south to north. In the Kalakot area, the sequence begins with coaly shales and becomes more marine upwards with olive green foraminiferal shales and dark gray lenticular nummulitic limestone. Above the Subathu is a zone that is transitional with the lower Murree Formation which consists of alternating dark red or brown indigo-blue colored clays, mud-cracked thinly laminated bluish-gray silstone and bone-bearing argillaceous limestone. Because of this contrast in lithology, the formational boundary was placed by some Indian geologists at the top of the uppermost fossiliferous limestone, just below the red clays. However, it has been shown that a red facies interfingers the dominantly green Subathu, which would make this placement of the boundary difficult to determine; it is now generally agreed that the Kalakot fossil beds are situated at the top of the Subathu in deposits that are transitional between the marine Subathu and the continental lower Murree [72 bis]. As pointed out by Karunakaran & Ranga Rao (1976), if the first appearance of the red beds over the green Subathu shales were to be taken as the base of the Murree Fm., the Subathu-Murree boundary would be time transgressive and include rocks deposited in different units.

The Subathu is underlain by the Sirban limestone (also called the Waishno [72] Devi limestone) of late Precambrian to early Cambrian age. The overlying Murree Fm. is dated as Miocene; Oligocene continental deposits have not yet been recognized in the Himalayan region.

Little material is known from the localities outside the Kalakot region, such as Mandi [73] and Subathu. But those that were discovered by the University of Michigan — Geological Survey of Pakistan teams east of Kotli, Kamroti [74] area, Nikial and Maklorhi have provided rather diverse asemblages.

A large tooth was found near Kamroti in the green sandstone that is regarded as the base of the Murree. In the upper 30 m of the Subathu, immediately below this bed, a sequence of fossiliferous sites were discovered (in descending order); in the transitional purple shale, in a

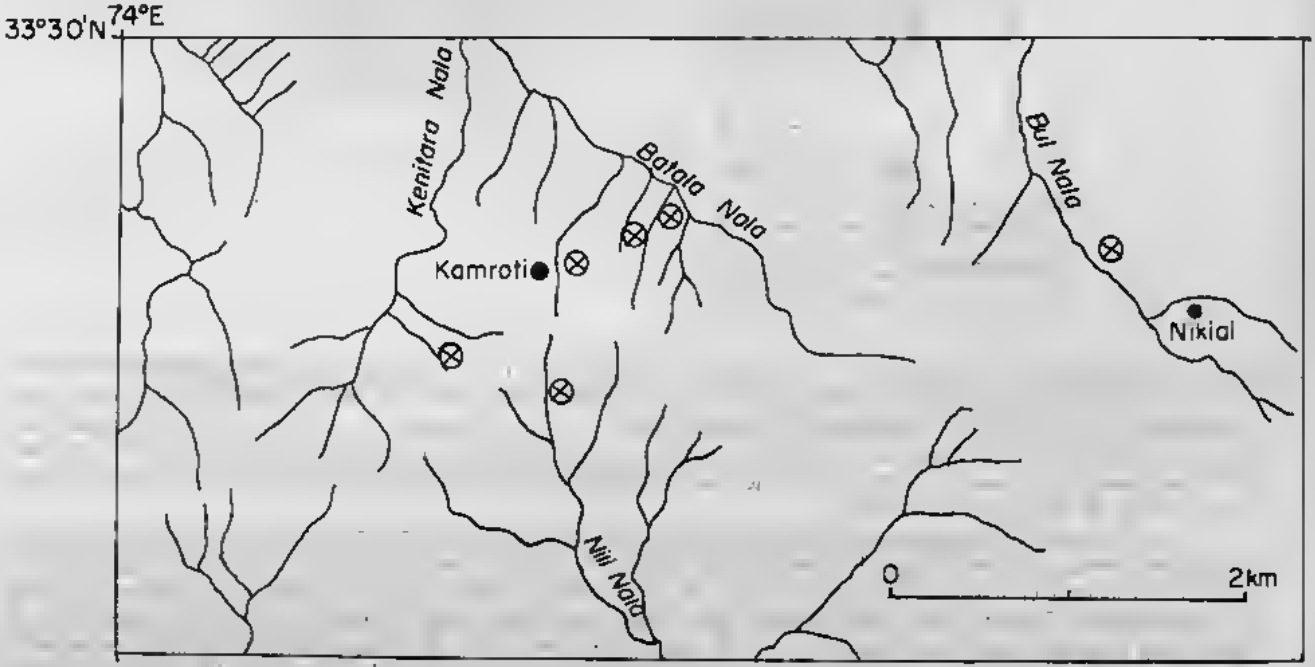


FIG. 67. — Sketch map of the fossil localities in the Subathu Fm. of the region of Kamroti, about 18 km southeast of Kotli, Azad Kashmir, Pakistan. From field notes (Russell, 1981).

72 Waishno (= Vaishno, Waishno Devil) = goddess of destruction and creation.

72 bis Ranga Rao has said (pers. com., 1987) that the transitional beds, containing the main vertebrate-bearing beds, are now considered as separate from the underlying marine sequence of the Subathu Fm. and will be designated the Kalakot Fm.

73 Mandi = market place.

74 Kamroti = Kam = little, roti = bread; poor country (of little bread).

Source : MNHN, Paris

yellow-green shale (the most productive), and below a brownish ledge-forming claystone in a shale and marl horizon. An oyster limestone bed underlies the latter and fish bone was recovered in a limestone and shale bed below it.

In the first articles describing the Kalakot fauna, Ranga Rao (1971) considered it to be younger than that of Ganda Kas and older than the Irdin Manha, Shara Murun and Pondaung faunas, while Sahni & Khare (1971) were of the opinion that it was more nearly contemporaneous with the Ganda Kas mammals. There is now agreement on a middle Eocene age for the Kalakot fauna. This is based to a large degree on Foraminifera in adjacent marine limestone, as little correlation by mammals can be obtained with other parts of Asia. The marine bed just below the mammal-bearing beds is dated as early Eocene; in the Kohat Basin of Pakistan the limestone immediately overlying the vertebrate bearing Kuldana Fm. (regarded as an approximate age equivalent to the Subathu Fm.) includes Foraminifera characteristic of the middle Eocene.

Fauna of the upper part of the Subathu Fm.

RODENTIA

CTENODACTYLIDAE

— *Birbalomys woodi* Sahni & Khare, 1973
(= *Metkamys blacki* Sahni & Srivastava' 1976, *in* Hartenberger, 1982)
(*Birbalomys* = *Saykanomys in* Hussain *et al.*, 1978; denied by Hartenberger, 1982)

— *Chapattimys debruijni* Hartenberger, 1982
(*Chapattimys* = *Metkamys in* Sahni, 1980; denied by Hartenberger, 1982)

— *Rajaurimys*; cited by Sahni *et al.*, 1981a, *nomen nudum* (= unnamed genus; cited by Sahni & Srivastava, 1977)

— Ctenodactylidae indet., *in* Hartenberger, 1982
(= *Franimys*? sp.; cited by Sahni & Srivastava, 1976)

CREODONTA

HYAENODONTIDAE

— *Paratritemnodon indicus* Ranga Rao, 1973

CONDYLARTHRA

MESONYCHIDAE

— cf. *Honanodon* sp.; cited by Ranga Rao, 1973

PERISSODACTYLA

BRONTOTHERIIDAE

— *Mulkrajanops moghliensis* Kumar & Sahni, 1985

ISECTOLOPHIDAE

— *Sastrilophus dehmi* Sahni & Khare, 1971

HELALETIDAE

— *Hyrachyus asiaticus* Ranga Rao & Obergfell, 1973

LOPHIALETIDAE

— *Kalakotia simplicidentata* Ranga Rao, 1972
(= *Chasmotherium mckennai* Sahni & Khare, 1973; opinion of the authors)
(= *Schlosseria radinskyi* Sahni & Khare, 1973; opinion of the authors)
(= *Aulaxolophus quadrangularis* Ranga Rao, 1972; opinion of the authors)

HYRACODONTIDAE

— *Triplopus kalakotensis* (Khan, 1973); opinion of the authors
(= *Prothyracodon? kalakotensis* Khan, 1973; Radinsky, 1967, referred the genus *Prothyracodon* to *Triplopus*)

HYRACODONTIDAE?

— "*Forstercooperia*" *jigniensis* (Sahni & Khare, 1973) Lucas *et al.*, 1981
(taxonomic position uncertain; not referable to *Forstercooperia*; *in* Lucas *et al.*, 1981

Source : MNHN, Paris

ARTIODACTYLA

DICHOBUNIDAE Indet.; cited by Sahni, 1979

RAOELLIDAE
- — *Khirtharia dayi* Pilgrim, 1940; cited by Sahni & Khare, 1973 (= *Bunodentus inflatus* Ranga Rao, 1972, *in* West, 1980)
- — *Haqueina haquei* Dehm & Oettingen-Spielberg, 1958; cited by Sahni & Khare, 1973
- — *Indohyus indirae* Ranga Rao, 1971 (= *Indohyus? kalakotensis* Ranga Rao, 1971; Ranga Rao, pers. com., 1977) (= *Raoella dograi* Sahni & Khare, 1971; opinion of the authors, but synonymy recognized *in* Sahni *et al.*, 1981a and b) (= *Kunmunella rajauriensis* Sahni & Khare, 1971; opinion of the authors) (= *Kunmunella transversa* Kumar & Shani, 1985; opinion of the authors.
- — *Metkatius kashmiriensis* Kumar & Sahni, 1985

PROBOSCIDEA

ANTHRACOBUNIDAE
- — *Pilgrimella pilgrimi*[75] Dehm & Oettingen-Spielberg, 1958; cited by Sahni & Khare, 1973 (= *Anthracobune pilgrimi* (Dehm & Oettingen-Spielberg, 1958) West, 1983)
- — *Anthracobune* sp.; cited by Sahni, pers. com., 1981 (from Balli)

Lat. 23° 30′ N, approx.
Long. 68° 30′ - 68° 45′ E, approx.

INDIA

GUJARAT STATE

Kachchh

Berwali Series; Babia Stage **middle Eocene**

Localities: Harudi, Naredi and Godhatad

Tertiary vertebrates from Kachchh[76] have been reported sporadically since 1840, but little intensive field work was done with the express aim of collecting them until 1970-1973, when parties from Lucknow University, during a total period of six months, succeeded in amassing an important collection. The Geological Survey of India also discovered cetacean material in this area during the same period.

The fossiliferous early Tertiary rocks (shell limestone, gypsiferous shales) in southwestern Kachchh form an essentially shallow water, coastal sequence. The early to middle Eocene Berwali[77] Series attains a maximum of 95 m; it is underlain by the Paleocene Madh Series and separated by a hiatus from the overlying Oligocene Bermoti Series.

Dating of the Babia Stage is based on assemblages of ostracods and Foraminifera. The cetaceans resemble those found in middle Eocene beds in Egypt and Nigeria, and a sirenian, first described from the middle Eocene of the Mokattam Hills, Cairo, is cited from the Kachchh deposits based on material that appears to be specifically identical. A sacrum referred to a terrestrial vertebrate might be attribuable to the Moeritheriidae.

75 Considered a perissodactyl by Coombs & Coombs, 1979; referred to the Moeritheriidae by West, 1983.
76 Kachchh (= Kutch) = turtle.
77 Berwali (ber = the fruit of an accacia-like tree; wali = pertaining to).

Source : MNHN, Paris

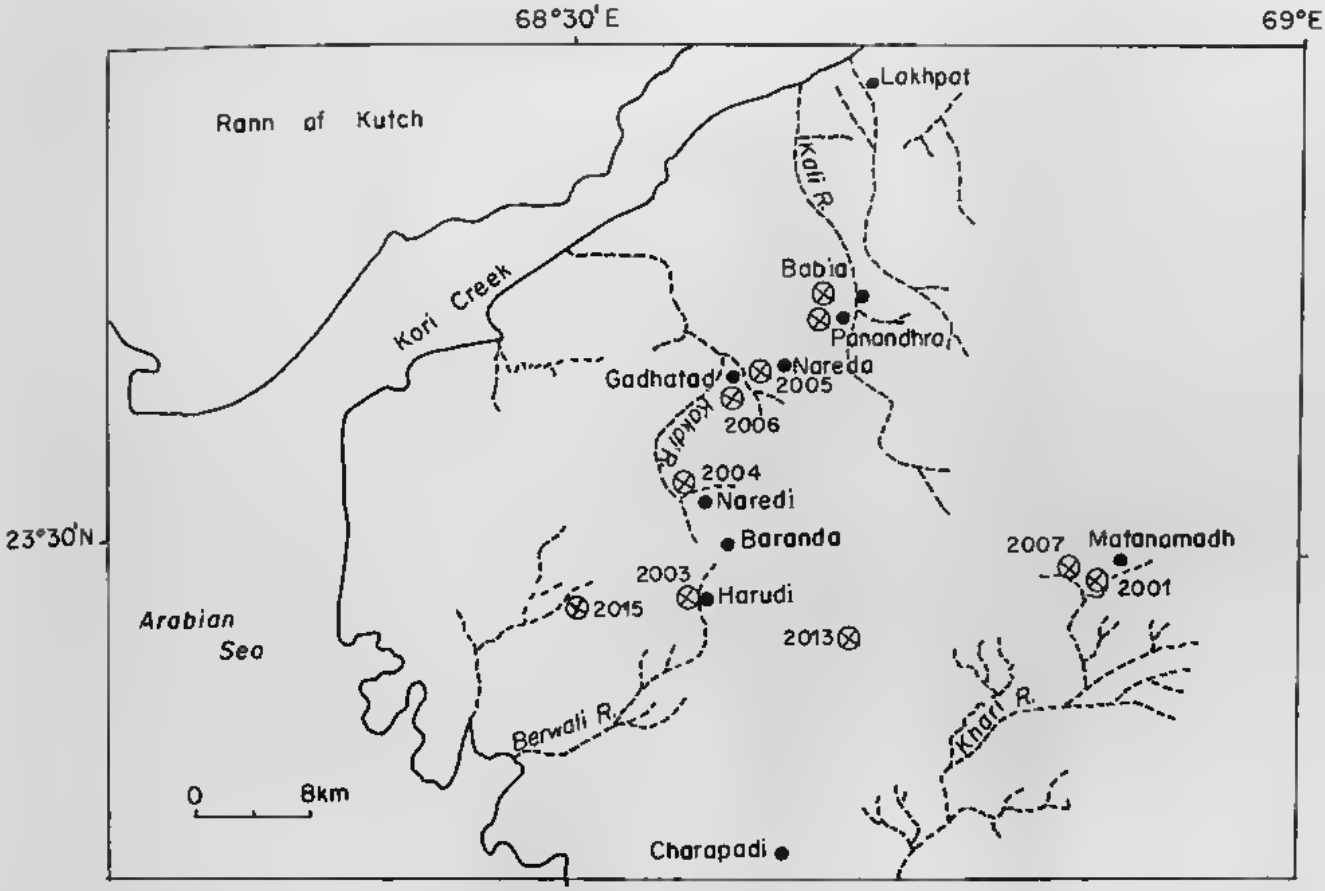


FIG. 68. — Sketch map of western Kachchh showing vertebrate fossil localities. Early Eocene, 2004; middle Eocene, 2003, 2005, 2006, 2013 and the localities west of Babia and Panandhro; late Oligocene?, 2001, 2007, 2015. Modified from Sahni & Mishra, 1975.

Fauna of the Berwali Series

CETACEA

PROTOCETIDAE — *Indocetus ramani* Sahni & Mishra 1975
— *Protocetus sloani* Sahni & Mishra 1972
— *Protocetus harudiensis* Sahni & Mishra 1975

AGOROPHIDAE — *Andrewsiphius kutchensis* Sahni & Mishra 1975
— *Andrewsiphius* Sahni & Mishra 1975

CETACEA Indet.; cited by Satsangi & Mukhopadhyay, 1975

SIRENIA

PROTOSIRENIDAE — *Protosiren fraasi* Abel, 1904; cited by Sahni & Mishra 1975

PROBOSCIDEA

MOERITHERIIDAE — cf. Moeritheriidae (sacrum); cited by Sahni & Mishra 1975

Source : MNHN, Paris

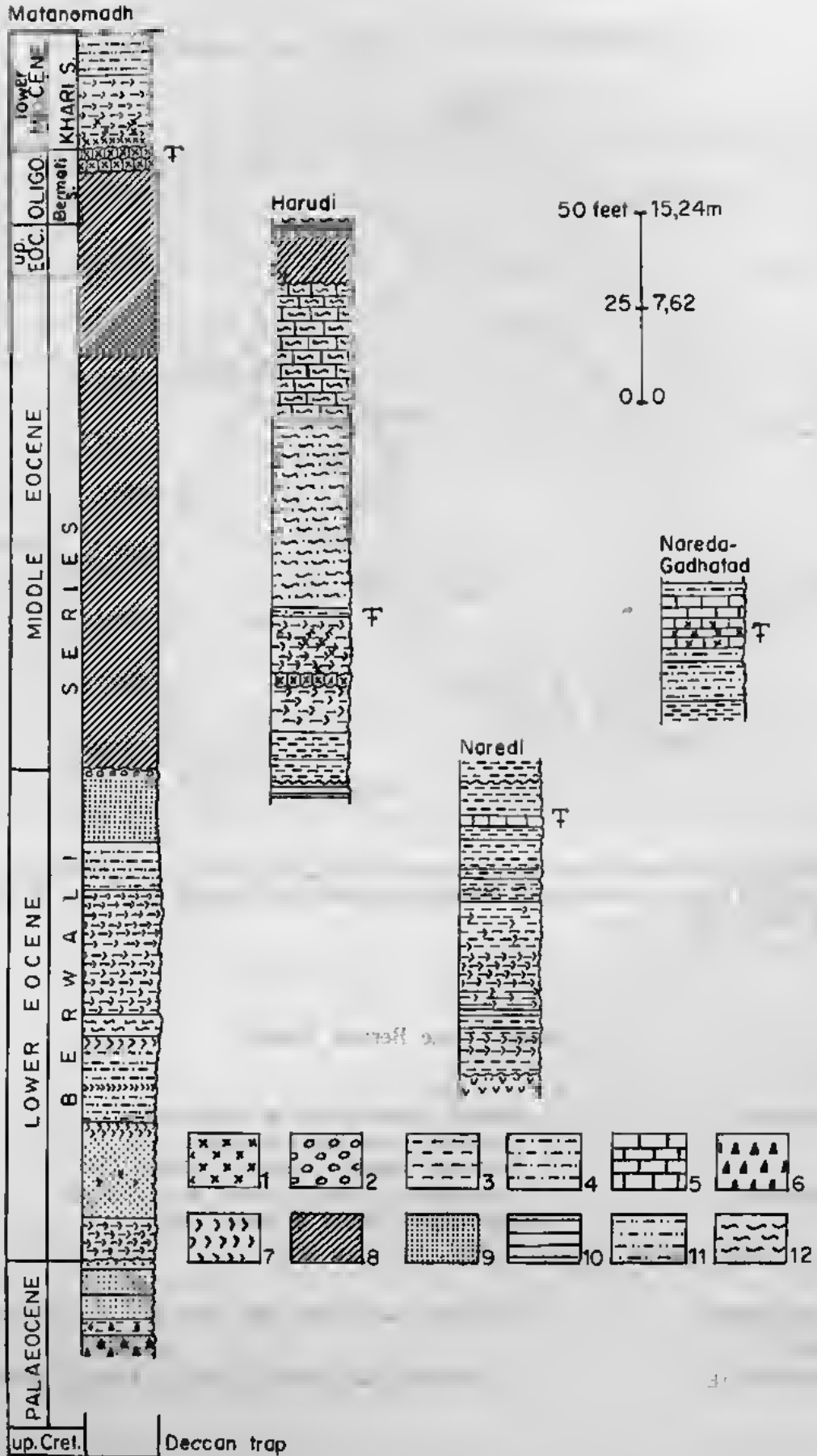


FIG. 69. — Measured stratigraphic sections showing the vertebrate levels of western Kachchh. **1.** vertebrate level; **2.** conglomerate; **3.** shale; **4.** arenaceous shale; **5.** limestone; **6.** tuff; **7.** gypseous; **8** hiatus; **9.** sandstone; **10.** clay; **11.** argillaceous sandstone; **12.** marl. Modified from Sahni & Mishra, 1975.

Source : MNHN, Paris

Lat. 44° N, approx.
Long. 100° E, approx.

Fig. 1, n° 10, 11

MONGOLIA

Zaaltay Gobi Province

Bugin-Tsav Basin

Khaychin Svita **middle Eocene**

Localities: Khaychin-Ula II, III and V

The locality of Khaychin-Ula was discovered in 1969 by V. F. Shuvalov, a geologist from the Institute of Limnology of the Academy of Sciences of the U.S.S.R. Field studies were conducted by crews led by Reshetov from 1970 to 1984 and screen-washing of the matrix was done along with classic collecting; the material is still incompletely studied. The site is situated in the Zaaltay Gobi, southwest Mongolia, in the Bugin-Tsav Basin, 59 km NW of Altan-Ula. The name comes from the (largely Cretaceous) hill of Khaychin-Ula, on the slopes of which fossiliferous sediments crop out in a series of ravines extending WSW-ENE over a distance of 20 km.

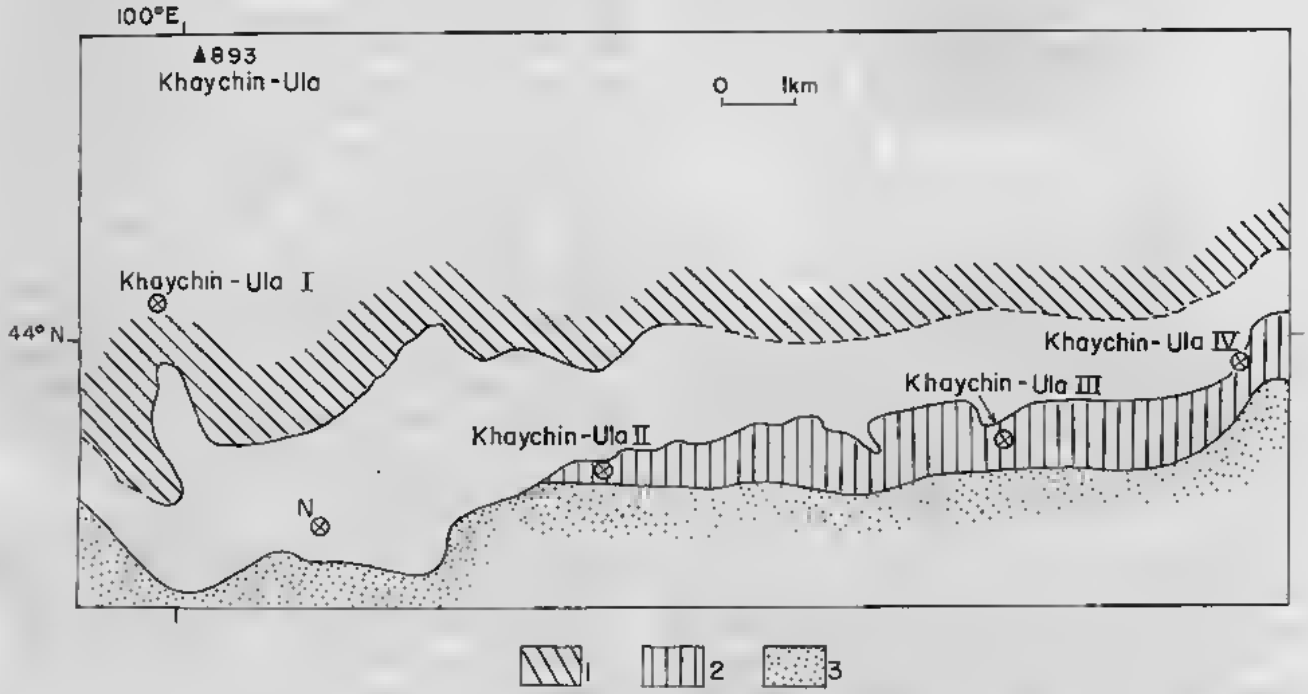


FIG. 70. — Detailed sketch map of the region containing the fossil localities near Khaychin-Ula Mountain, Mongolia. **1**. Late Cretaceous sediment; **2**. the middle Eocene Khaychin Svita; **3**. Gobi Conglomerate of Neogene to Quaternary age. The white area between the Cretaceous and Eocene sediments represents sandy valley bottom, overlying the Naran Member of the Naran-Bulak Svita. N: fossil mammal locality in the Naran Member. Modified from Badamgarav & Reshetov, 1985.

Reshetov, during his studies of the Paleogene deposits in the area, named a sequence of these ravines Khaychin-Ula I, II, III, IV and V.

We have seen that Khaychin-Ula I includes both a Cretaceous locality and one that is late Paleocene. Khaychin-Ula II is perhaps the most important of the Tertiary series and constitutes a large badland with many minor sites (a, b, c, etc.). Khaychin-Ula II and III may be considered as one site; only turtle remains are known from

Source : MNHN, Paris

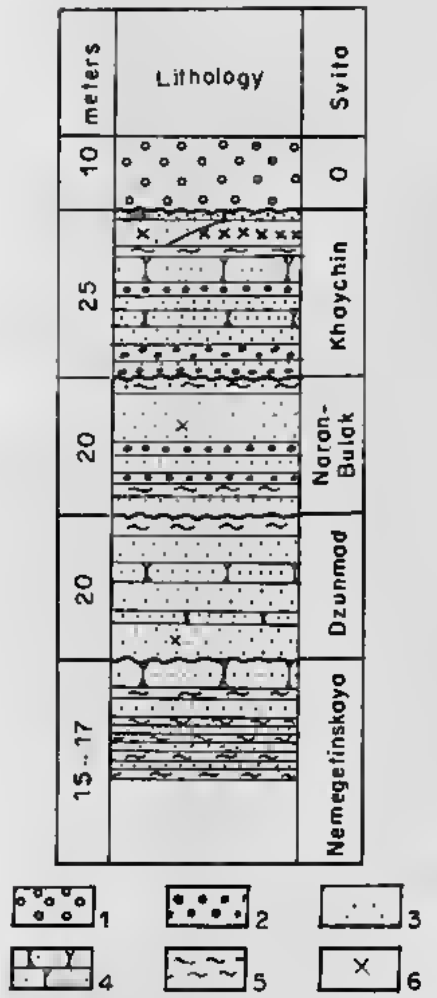


FIG. 71. — Stratigraphic section of the late Cretaceous and early Paleogene sediment of the Khaychin-Ula region, Bugin-Tsav Basin, Mongolia. 1. conglomerate; 2. gravels; 3. friable sandstone; 4. concretionary sandstone with bones; 5. clays; 6. fossil mammal level. Modified from Shuvalov, Reshetov and Barsbold, 1974.

Khaychin-Ula IV, and Khaychin-Ula V represents again the level at Khaychin-Ula II and III.

Khaychin-Ula V, which lies 16 km south of Khaychin-Ula II, was discovered by the South Gobi team of the Soviet-Mongolian Paleontologic Expedition, led by Reshetov and Badamgarav in 1973 and described by Badamgarav and Reshetov in 1976. Excavations were made in the years 1973 and 1976 and produced two species of *Protitan* and unidentified amynodont remains.

The geologic section of Khaychin-Ula consists of early Paleogene deposits unconformably overlying the late Cretaceous Nemegt Svita that is widely distributed in the Bugin-Tsav Depression. The early Tertiary is divided into a lower svita, the Naran-Bulak, and an upper one, the Khaychin Svita; they are individualized on both geologic and faunistic evidence and separated by an erosional unconformity.

It has been suggested (Shuvalov, Reshetov and Barsbold, 1974) that the section at Khaychin-Ula be considered as a stratotype of the early Paleogene; an essentially continuous section exists there from late Cretaceous to the late Eocene.

Demonstrating the vertical distribution of the fossiliferous sediments, a lens-like bone-bearing deposit, up to 1.5 m thick, occurs in the upper part of the Khaychin Svita at Khaychin-Ula II. Isolated bones were also found above this level, and *Lophialetes* was collected near the bottom of the svita. It should be noted that the division of the Khaychin Svita into a lower, Khaychin Member and an upper, Guril Member by Shuvalov *et al.*, (1974) was refuted by Badamgarav and Reshetov (1976), who discovered that the two members represented only different facies of the same beds. Devyatkin (1981), however, still retains the Guril Member as distinct.

The age of the Khaychin Svita is considered (by Shuvalov *et al.*, 1974) as middle-late Eocene. According to the rodents, which are also found in the Obayla Svita of the Zaysan Basin of Kazakhstan, and at Andarak in the Fergana Depression of Kirgizia, a middle Eocene age is indicated; Reshetov (1979) is also of the opinion that it is middle Eocene. A significant number of mammals (for example, *Microtitan, Protitan, Teleophus, Lophialetes, Breviodon, Forstercooperia* and *Gobiohyus*) are similar to those of the Irdin Manha fauna, placed in this work in the middle Eocene.

Other authors who have described the localities of Khaychin-Ula include Barsbold *et al.*, 1971; and Yanovskaya, 1975, 1980. For further references, see faunal list.

Source : MNHN, Paris

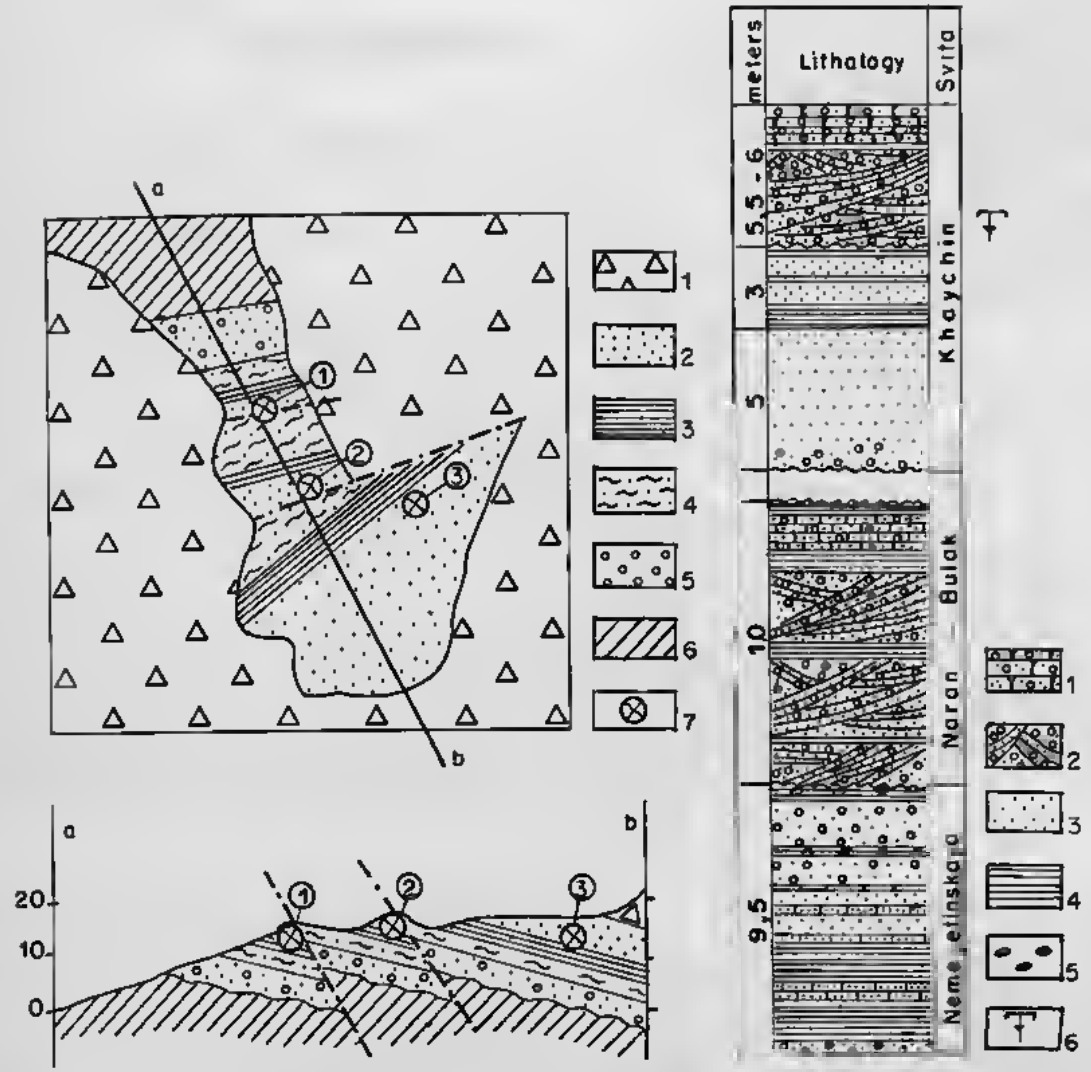


FIG. 72. — Geologic sketch of the locality of Khaychin-Ula V and cross section through the fossiliferous beds, Bugin-Tsav Basin, Mongolia. **1.** Quaternary blocks and gravels; Khaychin Svita sediments: **2.** sands; **3.** clay; **4.** argillaceous sandstone; **5.** gravel; **6.** Naran-Bulak Svita sediments; **7.** mammal localities. Modified from Badamgarav & Reshetov, 1976.

FIG. 73. — Stratigraphic section through the region of the Khaychin-Ula V locality, Bugin-Tsav Basin, Mongolia. **1.** sandstone; **2.** crossbedded sand; **3.** sand; **4.** clay; **5.** carbonate concretions; **6.** fossil mammal level. Modified from Badamgarav & Reshetov, 1976.

Faunal list from the Khaychin Svita at Khaychin-Ula II, III and V

INSECTIVORA

APTERNODONTIDAE Indet.; McKenna, pers. com., 1985

ERINACEOMORPHA Indet.; cited by Reshetov, 1975

PANTODONTA

CORYPHODONTIDAE — cf. *Eudinoceras* sp.; cited by Badamgarav & Reshetov, 1985

LAGOMORPHA Indet.; cited by Reshetov, pers. com., 1984

RODENTIA

CTENODACTYLIDAE — *Saykanomys chalchae* Shevyreva, 1972
— *Petrokozlovia notos* Shevyreva, 1972

Source : MNHN, Paris

CREODONTA

HYAENODONTIDAE — *Pterodon rechetovi* Dashzeveg, 1985

CONDYLARTHRA

MESONYCHIDAE — *Metahapalodectes makhchinus* Dashzeveg, 1976a
— *Mongolonyx robustus* Dashzeveg, 1976a

PERISSODACTYLA

BRONTOTHERIIDAE — *Microtitan mongoliensis* (Osborn, 1925) Granger & Gregory, 1943, cited by Yanovskaya, 1975
(= *Metarhinus mongoliensis* Osborn, 1925; cited by Reshetov, 1979
— *Protitan khaitshinus* Yanovskaya, 1980 [78]
— *Protitan reshetovi* Yanovskaya, 1980 [78]

DEPERETELLIDAE — *Teleolophus medius* Matthew & Granger, 1925f; cited by Reshetov, 1975
— *Teleolophus* sp.; Reshetov, pers, com, 1984
(= *Teleolophus magnus*? Radinsky, 1965; cited by Reshetov, 1979
— *Deperetella khaitchinulensis* Reshetov, 1979

LOPHIALETIDAE — *Lophialetes expeditus* Matthew & Granger, 1925f; cited by Reshetov, 1975
— *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975
(= *Lophialetes minutus* Matthew & Granger, 1925f)
(= *Breviodon? minutus* (Matthew & Granger, 1925f) Radinsky, 1965)

HYRACODONTIDAE — *Triplopus? proficiens* (Matthew & Granger, 1925f) Radinsky, 1967
(= *Caenolophus proficiens* Matthew & Granger, 1925f)
— *Forstercooperia totadentata* (Wood, 1938); cited by Badamgarav & Reshetov, 1985
(= *Forstercooperia* sp.; cited by Reshetov, 1975)

AMYNODONTIDAE Indet.; cited by Badamgarav & Reshetov, 1976
(= Ceratomorpha, cited by Badamgarav & Reshetov, 1976); Reshetov, pers. com., 1981

ARTIODACTYLA

HELOHYIDAE — *Gobiohyus* n. sp.; cited by Badamgarav & Reshetov, 1985
(= *Gobiohyus*? sp.; cited by Belyayeva *et al.*, 1974)

"HYPERTRAGULIDAE" Indet.; cited by Badamgarav & Reshetov, 1985

78 Found at Khaychin Ula V only.

Source : MNHN, Paris

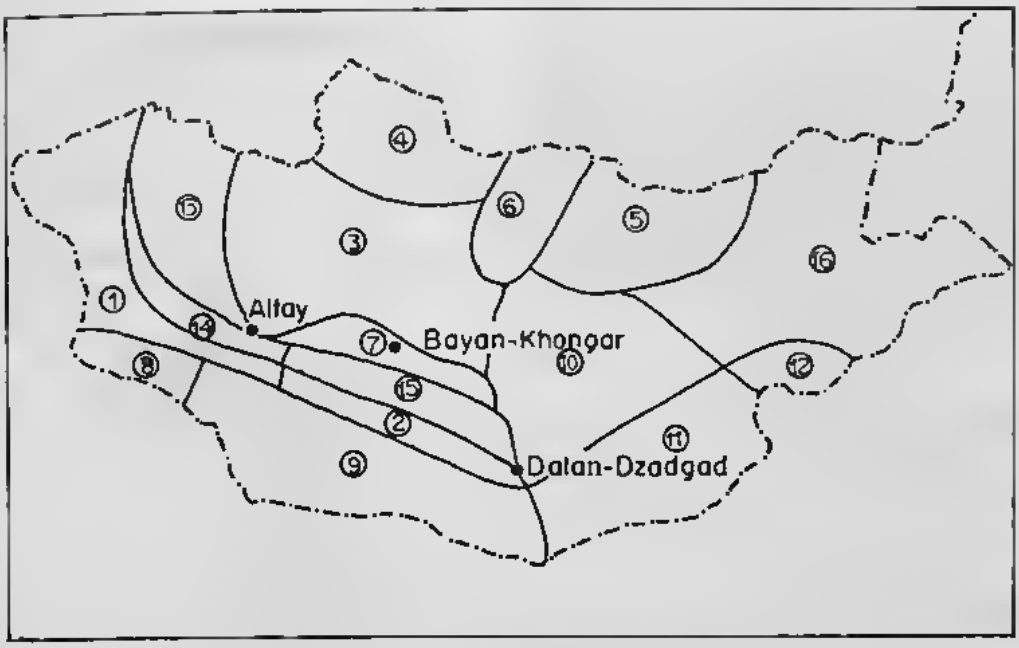


FIG. 74. — Sketch map of the structuro-geomorphic zones of Mongolia during Cenozoic time. **1.** Mongol Altay; **2.** Gobi Altay; **3.** Khangay; **4.** northern Mongolia; **5.** Khentey; **6.** Orkhon-Selengin; **7.** southern Khangay plateau; **8** Barun-Khuray depression; **9.** Zaaltay (south) Gobi; **10.** middle Gobi; **11.** southeast Gobi; **12.** Darigan-bulkanich plateau; **13.** basin of the Great Lakes; **14** pre-Altay depression; **15.** Valley of Lakes; **16.** the depression of northeast Mongolia. Modified from Devyatkin, 1981.

Lat. 45° 7′ - 45° 15′ N, approx.
Long. 100° 30′-100° 45′ E, approx. Fig. 1, n° 16, 18, 19

MONGOLIA
OBOR KHANGAY PROVINCE
Valley of Lakes Depression

Kholboldzhi-Nur Svita **middle Eocene**

Localities: Tsagan-Khutel, Barun-Khutsyn-Tsav, Menkhen-Teg

The Valley of Lakes[79] is an intermontane basin separating the Khangay[80] and the Gobi Altay[81]; it extends in an east-west direction over nearly 350 km, from the Beger[82] Basin to the town of Dalan-Dzadgad[83] in the east. In width it varies between 30 and 50 km, with a sharp southern limit formed by the tectonic face of the Gobi Altay; to the north rise the gentle slopes of the southern plateau of Khangay. Cenozoic deposits in the center of the basin reach a thickness of 500 m. They are best exposed in the river valleys that descend from the Khangay, in the sector between the Tuin-Gol[84] and the southern piedmont of the Ikh-Argalantu-Nuru[85] Mountains (about 25 km to the east of Shand-Gol).

Obor Khangay = Ovor Hangey = Ubur Khangai.
79 Valley of Lakes = Dolina Ozer (in Russian) = Tsagan Nor Basin of the American Museum expeditions.
80 Khangay = " the region that satisfies all needs ".
81 Gobi Altay = the meeting of the Gobi (a zone of arid pasture, not desert), and the Altay (= golden).
82 Beger = frozen?
83 Dalan-Dzadgad = (Dalan-Dzadagad) = 70 springs.
84 Tuin-Gol = the river toward which one goes.
85 Ikh-Argalantu-Nuru = big ram range.

Source : MNHN, Paris

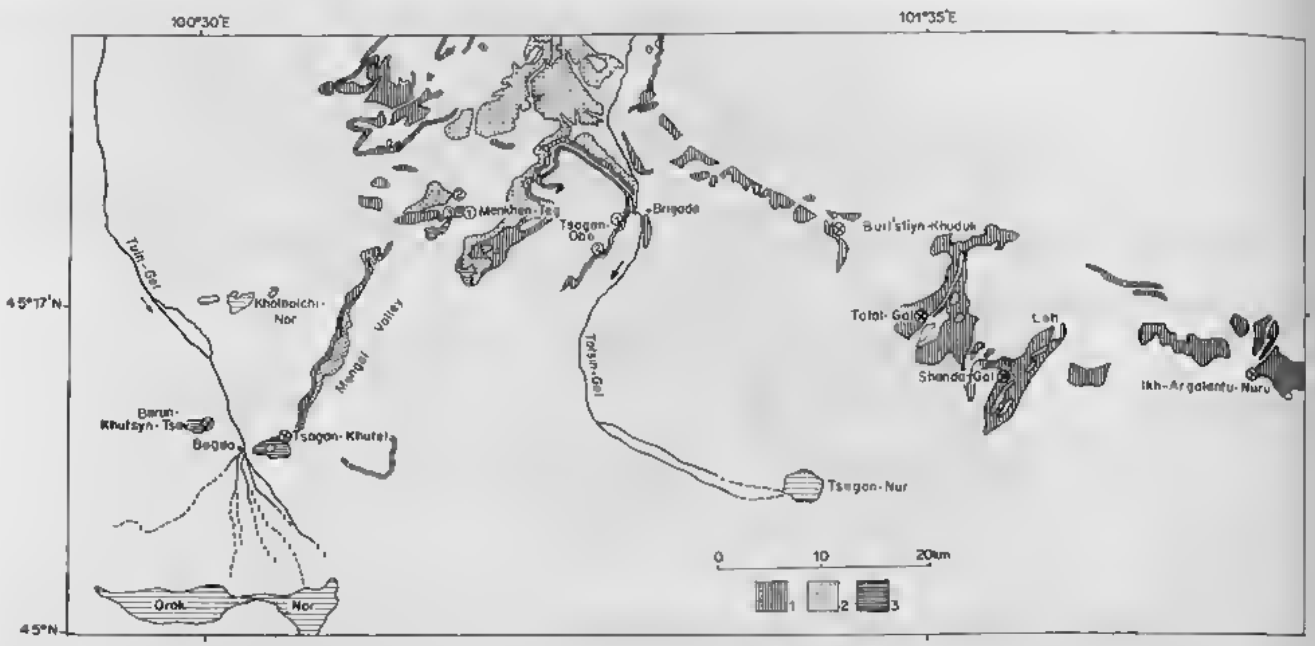


FIG. 75. — Central part of the Valley of Lakes, Mongolia, showing the position of the principal Paleogene localities. The Tsagan-Khutel locality is called Kholboldzi-Nur 1 by Devyatkin (1981); the same author refers to the Barun-Khutsin-Tsav locality as Kholboldzhi-Nur 2. MenkhenTeg 1 indicates the Eocene sediments of the Kholboldzhi Svita, low in the section; Menkhen-Teg 2 indicates the good exposures of the early Oligocene sediments of the middle of the section; Menkhen-Teg 3 indicates the outcrops of the middle Oligocene Shand-Gol Svita. **1**. Shand-Gol Svita; **2**. Ergilin-Dzo Svita; **3**. Kholboldzhi-Nur Svita. Modified from Badamgarav *et al.*, 1975.

The sediments of the Kholboldzi-Nur [86] Svita form the lowest part of the Paleogene in the Valley of Lakes, as they lie directly on Paleozoic rocks (or, in the east, on early Cretaceous deposits); they are overlain by rocks analogous to the early Oligocene Ergilin-Dzo Svita at Tsagan Khutel [87] and Menkhen-Teg [88] and are everywhere capped by an erosional surface; Neogene sediments overlie the Kholboldzhi-Nur Svita at Barun-Khutsin-Tsav [89]. The svita is characterized by light yellow argillaceous sand and sandstone, brownish red or brownish clay, pelite and sand, with lenses of altered gravel. At Menkhen-Teg a prominent bed of brick red clay (up to 10 m) acts as a marker horizon for the top of the Eocene beds in that area. The thickness of the Kholboldzhi-Nur is about 20 m at Tsagan-Khutel, 16 m at Barun-Khutsin-Tsav, and 15 m at Menkhen-Teg. The latter region offers the most complete section for the area, with beds ranging in age from Eocene to Pliocene; with more detailed work it could become very important biostratigraphically.

The American Museum Central Asiatic Expedition of 1925 discovered Eocene mammals in outcrops north of Lake Orok-Nur on the left bank of the Tuin-Gol and about 2 km east of the somon (county seat) of Bodgo. This area was taken as the stratotype of the Kholobolchi Formation by Berkey *et al.*, (1929), not because of a particular proximity of the lake, Kholoboldzhi-Nur, but because the latter is a well known landmark in the region. The mammal locality was made known by its Mongolian name, Tsagan-Khutel, by Dashzeveg (1979a), who worked there in 1963 and 1967. Sands in the middle part of the svita have produced most of the mammalian fossils; Badamgarav *et al.*, (1975), who studied the geology of the region in 1971-1972, qualify this as the upper part of the svita. Only turtle fragments are known from the lower part.

The locality of Barun-Khutsin-Tsav was found

86 Kholboldzhi (= Kholobolchi-Nur (or Nor) = Kholbolchi) = between 2 lakes.
87 Tsagan-Khutel = white steep slope.
88 Menkhen-Teg = dune plain.
89 Barun-Khutsin-Tsav = western ram cliff.

Source : MNHN, Paris

by Dashzeveg in 1976, 2.5 km northwest of the county seat of Bogdo on the left bank of the Tuin-gol. The exposed sediments correspond approximately to those in the section at Tsagan-Khutel. *Gobihippus menneri, Breviodon* sp., *Pantolambdodon bogdensis* and *Hapalodectes* sp. were discovered here.

The third promising outcrop of the Kholboldzhi-Nur Svita occurs at Menkhen-Teg, 20-25 km NW of the section at Tsagan-Khutel and on the east slope of the Mongolian [90] Valley, 2 km SW of the well at Gun-Khuduk. Fossil mammals occur principally in the upper part of the svita, below the marker bed of red clay; Dashzeveg has identified *Teilhardia* sp. from here and Reshetov, *Breviodon* sp. A few bones of large mammals are known from the lower part of the svita, along with turtle fragments.

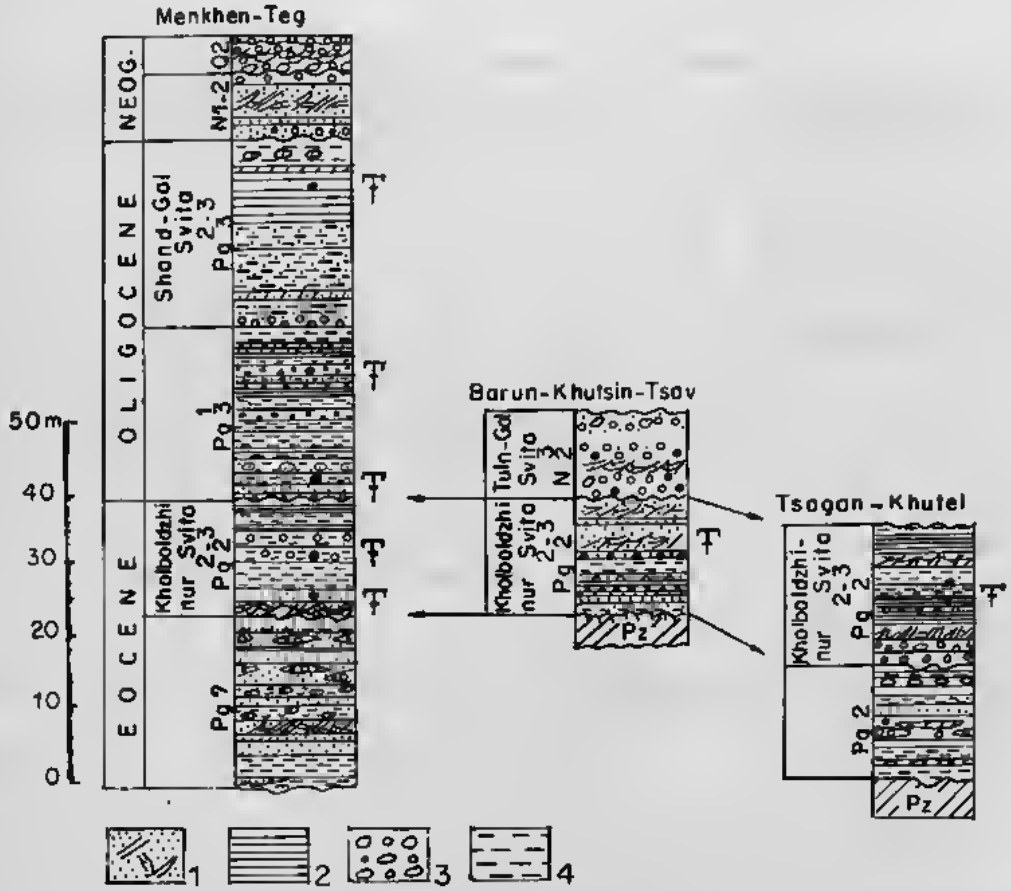


FIG. 76. — Sections in the western part of the Valley of Lakes, showing the situation of the Kholboldzhi-Nur Svita in the three principal localities of Menkhen-Teg, Barun-Khulsin-Tsav and Tsagan-Khutel; the latter is in the region of the type section of the svita. 1. crossbedded sand; 2. clay; 3. gravel or coarse sand; 4. silt. Modified from Badamgarav *et al.*, 1975.

An unnamed locality was discovered by the Valley of Lakes team led by Kurochkin in 1972 in an argillaceous gravel level high in the section, north of Lake Orok-Nur on the left bank of the Tuin-Gol and, according to Yanovskaya (1980) about 2 km east of Bodgo. This, however, corresponds to the position of the Tsagan-Khutel locality. Reshetov (pers. com., 1984) asserts that the site mentioned by Yanovskaya is indeed the latter. " Tapiroids and other mammals " including brontotheres, were cited by Yanovskaya (1980).

The Eocene sediments of the Zaaltay Gobi (the Khaychin Svita) and of the Valley of Lakes (Kholboldzhi-Nur Svita) are similar in lithological

90 This valley was misidentified by members of the American Museum Expeditions, who called it Khunuk (Khunuk = wooden bucket; also, a depression).

Source : MNHN, Paris

characters and in their stratigraphic position in the general Paleogene section. For many years their faunas have been considered as straddling the middle Eocene-late Eocene boundary. This was based on comparison with the Chinese assemblages of Nei Mongol, wherein the Arshanto and Tukhum mammals alone were thought to represent the middle Eocene and those of Irdin Manha and Ulan Shireh the late Eocene. Following the concept advocated here, both the Khaychin Svita, with a fauna that can be easily correlated with that of Irdin Manha, and the Kholboldzhi-Nur Svita (with *Pantolambdodon*, *Eudinoceras*, *Schlosseria*, *Lophialetes*, *Breviodon*, *Rhodopagus* and *Teilhardia*?) logically should be integrated into the middle Eocene Irdin Manha group of faunas.

Fauna of the Kholobolzdhi-Nur Svita

(* Tsagan-Khutel; ** Barun-Khutsyn-Tsav; *** Menkhen-Teg; **** unnamed locality (= Tsagan Khutel))

PROTEUTHERIA

PANTOLESTIDAE — * *Bodgia orientalis* Dashzeveg & Russell, 1985

PANTODONTA

PANTOLAMBODODONTIDAE — * *Archaeolambda prima* (Dashzeveg, 1980) Lucas, 1982 (= *Oroklambda prima* Dashzeveg, 1980)
— ** *Pantolambdodon bodgensis* Dashzeveg, 1980

CORYPHODONTIDAE — * *Eudinoceras kholobolchiensis* Osborn & Granger, 1931

* LAGOMORPHA? Indet.; cited by Manning, pers. comm., 1977

PERISSODACTYLA

**** BRONTOTHERIIDAE Indet.; cited by Yanovskaya, 1980

EQUIDAE — *Gobihippus menneri* Dashzeveg, 1979a[91]

* ISECTOLOPHIDAE Indet.; cited by Reshetov, 1975

LOPHIALETIDAE — * *Schlosseria* sp.; cited by Manning, pers. com., 1977
— *Lophialetes expeditus*? Matthew & Granger, 1925f; cited by Reshetov, 1975
— * *Lophialetes*? sp.; cited by Manning, pers. com., 1977
— ** *Breviodon* sp.; cited by Dashzeveg, 1979a
— *** *Breviodon* sp.; identified by Reshetov; cited by Devyatkin, 1981
— **** "Tapiroids and other mammals"; cited by Yanovskaya, 1980

LOPHIALETIDAE? — * *Rhodopagus* sp.; cited by Reshetov, 1975
— * *Pataecops parvus* (Radinsky, 1965) Radinsky, 1966 (= *Pataecus parvus* Radinsky, 1965)

AMYNODONTIDAE — *** *Teilhardia*? sp.; identified by Dashzeveg; cited by Devyatkin, 1981

91 J. J. Hooker (pers. com., 1986) regards this form as a brontothere.

Source : MNHN, Paris

Lat. 43°47′ N
Long. 111°43′ E

Fig. 1, n° 32

MONGOLIA

Dornogobi Province

unnamed svita **middle Eocene**

Locality: Mergen

The locality of Mergen[92] was discovered by Dashzeveg in 1982 during the Soviet-Mongolian Paleontologic Expedition of that year. The locality is situated in a southeasterly facing cliff about 23 km NW of Dzamyn-Ude and about 10 km west of the railroad line that connects the latter to Ulan Bator.

The fossiliferous sediments are principally white sand and sandstone, measuring about 15 m in thickness. They form the surface of the outcrop and are underlain by 7.5 - 8 m of red clay and sandstone. From their stratigraphic position Dashzeveg (pers. com., 1985) considers the latter beds to be equivalent to the Arshanto Formation of Nei Mongol. Correlation of the upper beds with the Irdin Manha Formation seems probable in view of the recovered fauna.

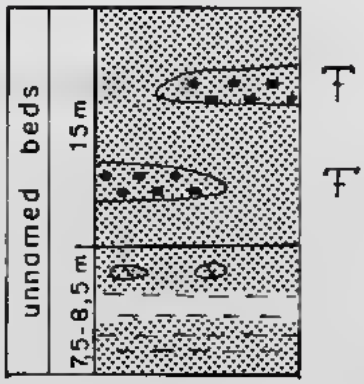


Fig. 77. — Stratigraphic section of the fossil mammal locality at Mergen, Mongolia. Data from Dashzeveg, pers. com., 1985.

Fauna of the unnamed svita at Mergen

LAGOMORPHA

Leporidae — *Shamolagus* or *Gobiolagus* sp.; cited by Dashzeveg, pers. com., 1985

RODENTIA

Ctenodactylidae[93] — *Yuomys* sp.; cited by Dashzeveg, pers. com., 1985

CONDYLARTHRA

Mesonychidae — *Harpagolestes*? cf. *orientalis* Szalay & Gould, 1966; cited by Dashzeveg, pers. com., 1985

PERISSODACTYLA

Lophialetidae — *Lophialetes expeditus* Matthew & Granger, 1925f; cited by Dashzeveg, pers. com., 1985

— *Breviodon minutus* (Matthew & Granger, 1925f) Reshetov, 1975 (= *Lophialetes minutus* Matthew & Granger, 1925f) (= *Lophialetes*? *minutus* (Matthew & Granger, 1925f); cited by Dashzeveg, pers. com., 1985)

92 Mergen = wise.
93 See footnote n° 11, p. 77.

Source : MNHN, Paris

HYRACODONTIDAE — *Triplopus*? *proficiens* (Matthew & Granger, 1925f) Radinsky 1967; cited by Dashzeveg, pers. com., 1985
(= *Caenolophus proficiens* Matthew & Granger, 1925f)

ARTIODACTYLA

HELOHYIDAE — *Gobiohyus* sp.; cited by Dashzeveg, pers. com., 1985

Lat. 33° 15′ N - 34° N, approx.
Long. 71° E - 73° 30′ E, approx.

PAKISTAN

NORTH WEST FRONTIER AND PUNJAB PROVINCES

Kuldana Formation **middle Eocene**

Localities: Kohat Basin (N.W. Frontier Prov.): Chorlakki, Panoba, Band Khula, Mazari Tang, Shadi Khel, Umer Khan, Shekhan Nala, Jatta, Jozara; Kala Chitta Hills (Punjab Prov.): Lammidhan, Ganda Kas, Jhalar, Chharat; Murree: Kuldana

Vertebrate fossils have been cited from the Eocene beds of northern Pakistan as early as 1877 and 1887. Research began gathering momentum with the descriptions by Pilgrim (1940), Dehm *et al.* (1958) and Dehm and Œttingen-Spielberg (1958) and extensive work was done in the late 1970's and early 1980's by parties from the University of Michigan and Howard Univer-

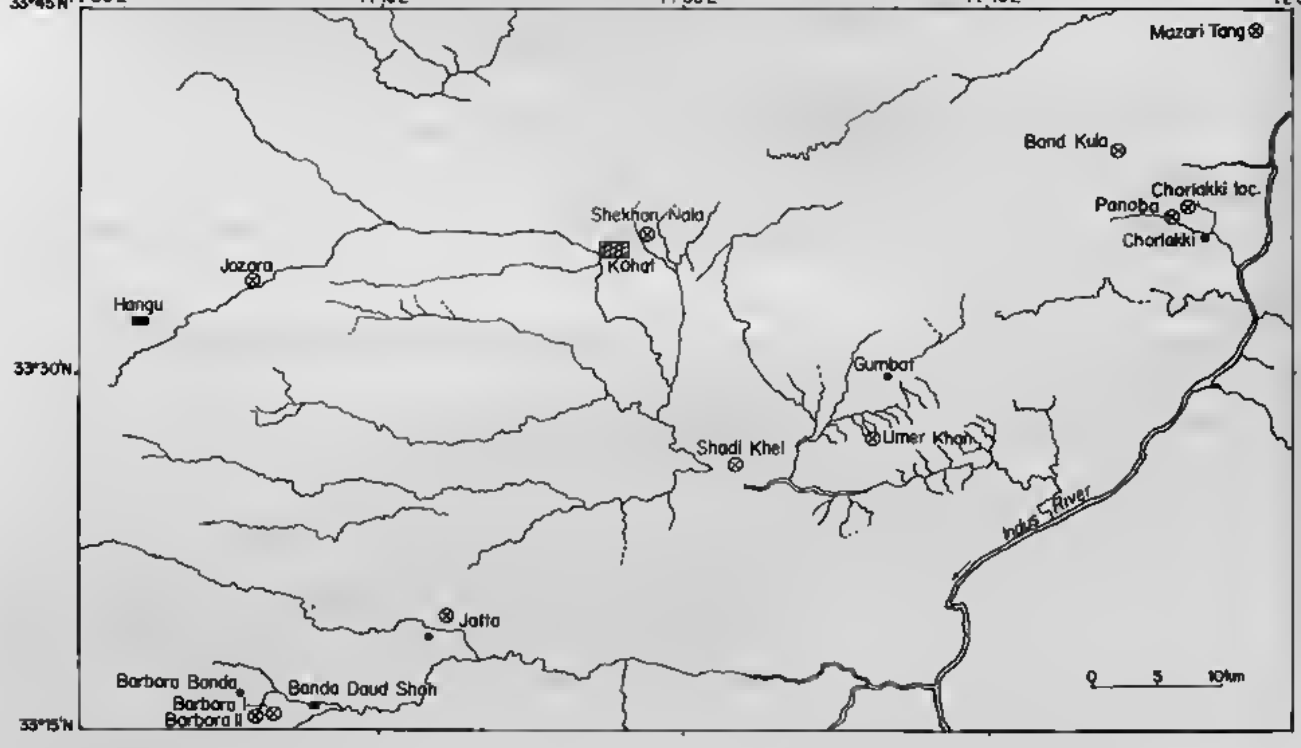


FIG. 78. — Map of the Kohat Basin, Pakistan, showing the fossil mammal localities of the Kuldana Formation. Modified from Meissner *et al.*, 1974.

Source : MNHN, Paris

sity in collaboration with the Geological Survey of Pakistan.

The mammal producing level, the Kuldana Formation, crops out in the Himalayan foot hills of Pakistan from the region of Rawalpindi (in the east) to west and south of Kohat. Many localities are concentrated in the areas near Ganda Kas (see West & Lukacs, 1979), Lammidhan (Gingerich, 1977) and Jhalar (Hussain *et al.*, 1978); others are west of the Indus in the Kohat District: from the vicinity of Chorlakki[94] and Panoba[95] in the east, to south of Gumbat,

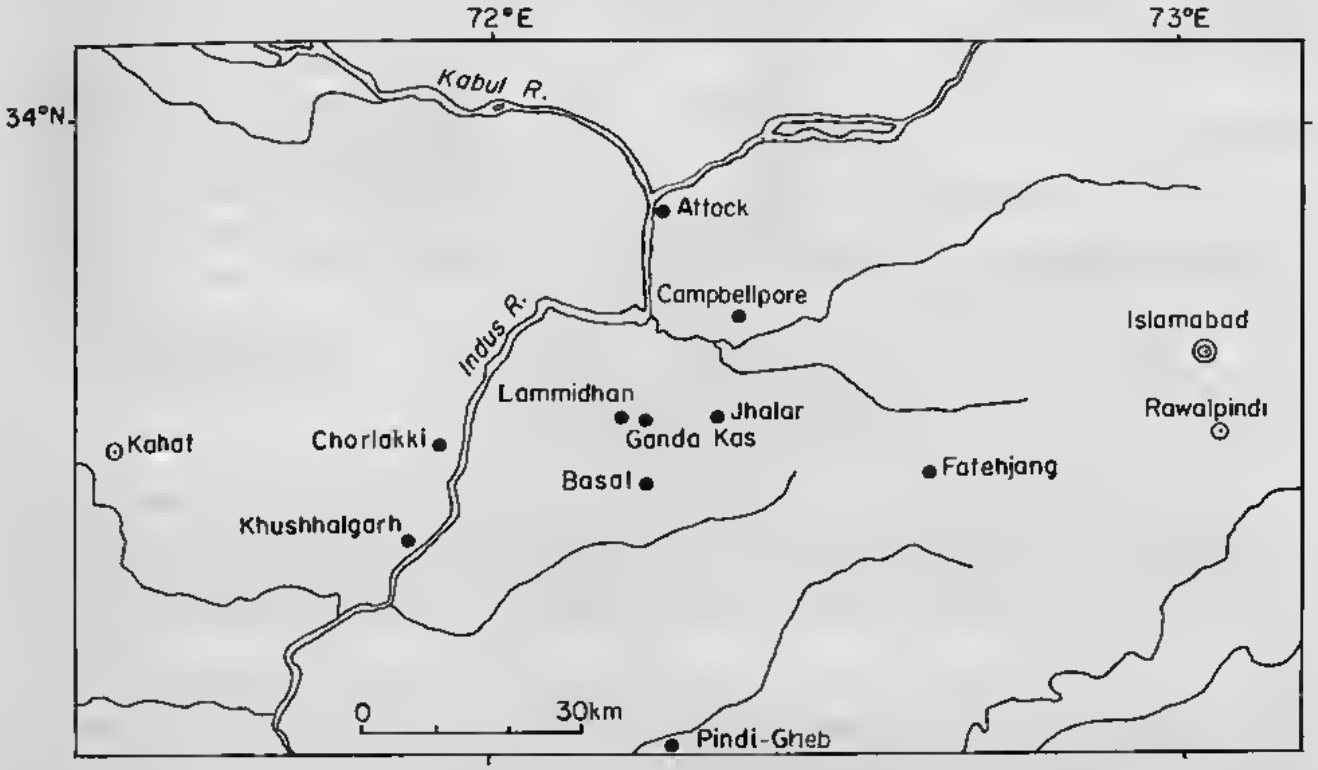


FIG. 79. — Map of the Kala Chilla Hills area, Pakistan, showing the position of the villages near which particularly rich collections of Eocene mammals have been made: Chorlakki, Lammidhan, Ganda Kas and Jhalar. From field notes (Russell, 1977-1981).

Shadi Khel, Shekhan Nala (Gingerich *et al.*, 1979a), Jatta, to the northwest at the Jozara Rest House (Wells and Gingerich, 1983) and south to the localities west of Banda Daud Shah near the village of Barbora. Chorlakki is the principal producing site, but excellent material (though little varied) has been recovered from Barbora (Thewissen *et al.*, 1983; Russell *et al.*, 1983; Sigogneau-Russell & Russell, 1983). To the east of Rawalpindi, in Pakistani (or Azad) Kashmir, and situated in the Subathu Formation, mammals approximately contemporaneous with those from western Pakistan have recently been discovered; these are discussed under that formation.

The section including the Kuldana Formation has undergone intense structural deformation, which makes for considerable difficulty in correlating within the formation. The Kuldana beds are overlain by the Kohat Limestone, underlain by the Shekhan Limestone and the Jatta Gypsum and can be divided into upper and lower parts. The lower Kuldana comprises uniform red clay with thin beds of calcareous grit, representing short-lived river channel deposits, from which nearly all of the collections of mammals have been made. It is thickest west of the Indus where it averages 120 m. The upper Kuldana, composed of variegated shale, limestone, dolom-

94 Chorlakki: the precise fossil locality is called Ziro (man's name) Gujer (a dairy products caste designation (= "the milk man"); also called Ziro Wala

95 Panoba: good water.

Source : MNHN, Paris

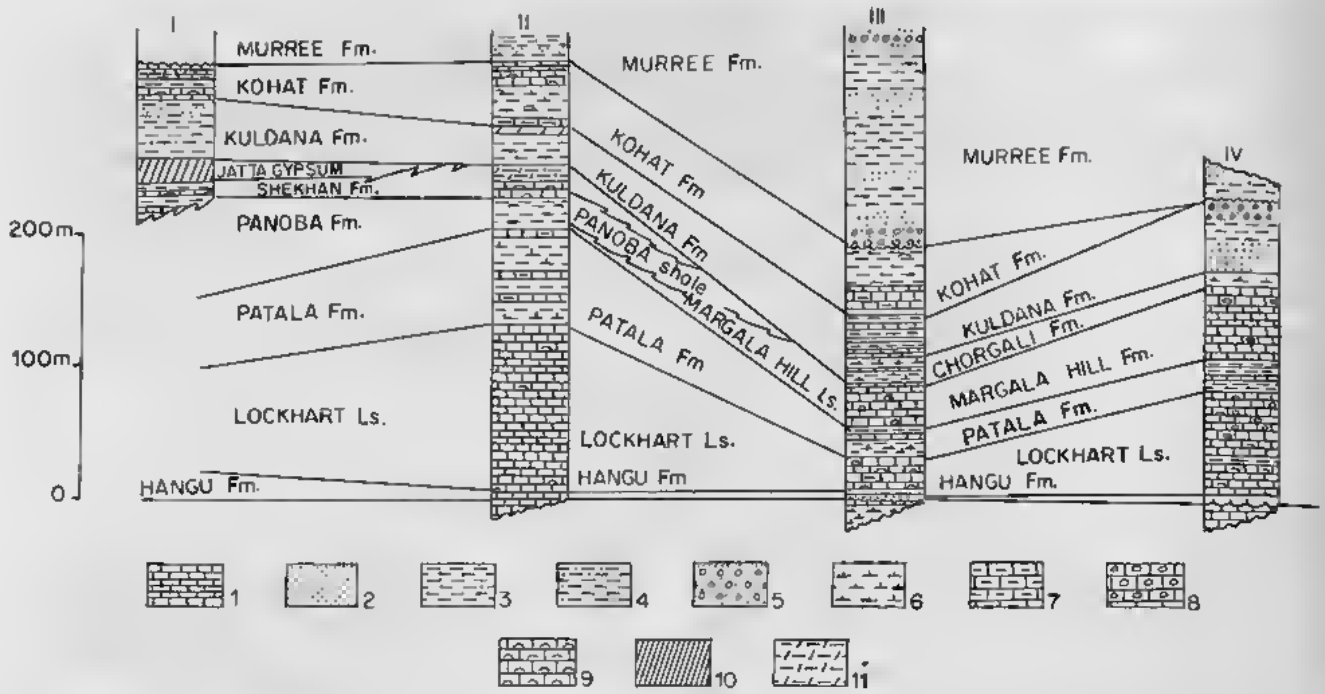


FIG. 80. — Correlations of lithostratigraphic sections in the early Cenozoic of northern Pakistan. I, in the Banda Daud Shah area; II, in the Shekhan-Chorlakki area; III, in the Kala Chitta hills; IV, in the type area of the Kuldana Fm. (near Kuldana village). Except for the latter section the true thickness of the Murree Fm. is not indicated. **1**. limestone; **2** sandstone; **3**. shale; **4**. sandy shale; **5**. sandy breccia or conglomerate; **6**. calcareous limestone; **7**. argillaceous limestone; **8**. concretionary limestone; **9**. limestone with shells; **10**. gypsum; **11**. gypsiferous shale. Modified from Shah, 1977.

ite, chert, sandstone and gypsum, represents various transitional-marine environments: estuarine, coastal plain lakes, hypersaline lagoons, beaches and protected bays. West of the Indus the lower Kuldana averages 10 m in thickness, but to the east the transitional facies of the upper Kuldana, with interbedded redbeds and marine shales, exceed 475 m.

Dating of the Kuldana fauna has been based on marine fossils from the overlying Kohat Limestone that indicate the early half of the middle Eocene, and from the Shekhan Limestone which can be dated as early Eocene. The limit between the early and the middle Eocene is uncertainly situated between the Kohat and Shekhan Limestones and, thus, above, below or within the Kuldana Formation. Furthermore, another possible margin of imprecision concerns the contact between the Kohat Limestone and the Kuldana Formation which has been sometimes considered diachronous. This concept would result in the top of the Kuldana being older to the west. The problem is still under study, but it is also possible that the localities are situated lower in the section to the west, producing elements of a late early Eocene fauna, whereas further east the localities may be stratigraphically higher, yielding an assemblage that is dominantly middle Eocene.

Fauna of the Kuldana Formation

INSECTIVORA

FAMILY Indet. — *Seia shahi* Russell & Gingerich, 1981

PROTEUTHERIA?

FAMILY Indet. — *Pakilestes lathrius* Russell & Gingerich, 1981

CHIROPTERA Indet. A; cited by Russell & Gingerich, 1981

CHIROPTERA Indet. B; cited by Russell & Gingerich, 1981

Source : MNHN, Paris

PRIMATES

OMOMYIDAE — *Kohatius coppensi* Russell & Gingerich, 1980

ADAPIDAE Indet,; opinion of the authors

TILLODONTIA

TILLOTHERIIDAE — *Basalina basalensis* Dehm & Œttingen-Spielberg, 1958

— cf. *Basalina basalensis* Dehm & Œttingen-Spielberg, 1958, *in* Lucas & Schoch, 1981a
(= *Taeniodontium* indet.; cited by Dehm & Œttingen-Spielberg, 1958)

RODENTIA

CTENODACTYLIDAE — *Birbalomys woodi* Sahni & Khare, 1973; cited by Hartenberger, 1982
(= *Chapattimys ibrahimshahi* Hussain *et al.*, 1978, *in parte in* Hartenberger, 1982)

— *Birbalomys sondaari* (Hussain *et al.*, 1978) Hartenberger, 1982
(= *Saykanomys sondaari* Hussain *et al.*, 1978)

— *Birbalomys ijlsti* (Hussain *et al.*, 1978) Hartenberger, 1982
(= *Saykanomys ijlsti* Hussain *et al.*, 1978)
(= *Saykanomys chalchae* Shevyreva, 1972; cited by Hussain *et al.*, 1978, *in parte in* Hartenberger,1982)

— *Birbalomys vandermeuleni* (Hussain *et al.*, 1978) Hartenberger, 1982
(= *Saykanomys vandermeuleni* Hussain *et al.*, 1978)
(= *Saykanomys lavocati* Hussain *et al.*, 1978, *in parte in* Hartenberger, 1982)

— *Chapattimys wilsoni* Hussain *et al.*, 1978
(*Chapattimys* = *Metkamys in* Sahni, 1980; denied by Hartenberger, 1982)

— *Chapattimys debruijni* Hartenberger, 1982

— *Gumbatomys asifi* Hartenberger, 1982

— cf. *Petrokozlovia* sp. indet. 1 & 2; cited by Hartenberger, 1982

— Rodentia indet., *in* Hartenberger, 1982
(= Ischyromyidae indet.; cited by Hussain *et al.*, 1978)

PERISSODACTYLA

BRONTOTHERIIDAE — *Eotitanops*[96] *dayi* (Dehm & Œttingen-Spielberg, 1958) West, 1980
(= *Eotitanops? dayi* Dehm & Œttingen-Spielberg, 1958)

— *Pakotitanops latidentatus* West, 1980

DEPERETELLIDAE — *Teleolophus? daviesi* Dehm & Œttingen-Spielberg, 1958 (possibly generically distinct from *Teleolophus, in* Radinsky, 1965)

HELALETIDAE — cf. *Hyrachyus asiaticus* Ranga Rao & Obergfell, 1973; opinion of the authors

LOPHIALETIDAE — *Kalakotia simplicidentata* Ranga Rao, 1972; opinion of the authors

ARTIODACTYLA

DICHOBUNIDAE — *Chorlakkia hassani* Gingerich *et al.*, 1979b

— *Dulcidon gandaensis* (Dehm & Œttingen-Spielberg, 1958) Van Valen, 1965a
(= *Promioclaenus? gandaensis* Dehm & Œttingen-Spielberg, 1958)

— *Diacodexis pakistanensis* Thewissen *et al.*, 1983

96 *Eotitanops* was regarded as a junior synonym of *Palaeosyops* in an unpublished master's thesis by Wallace (1980); cited by Stucky & Krishtalka, 1983.

Source : MNHN, Paris

— Dichobunidae indet.; cited by Thewissen *et al.*, 1983 (GSP-UM 259; M/3)

ANTHRACOTHERIIDAE
— cf. *Anthracokeryx* sp.; cited by Gingerich *et al.*, 1979b (referred to *Lammidhania wardi* by Gingerich, 1977)[96bis]
(= *Anthracokeryx birmanicus* Pilgrim & Cotter, 1916, *in* Coombs & Coombs, 1977)

RAOELLIDAE
— *Khirtharia dayi* Pilgrim, 1940
— *Indohyus* cf. *indirae*, Ranga Rao, 1971; cited by Gingerich *et al.*, 1983)
(= Mesonychidae indet,; cited by West, 1980, *in* Gingerich & Russell, 1981)
— *Haqueina haquei* Dehm & Œttingen-Spielberg, 1958

HELOHYIDAE
— *Gobiohyus* cf. *orientalis* Matthew & Granger, 1925e; cited by West, 1980

PROBOSCIDEA

ANTHRACOBUNIDAE
— *Anthracobune pinfoldi* Pilgrim, 1940
(= *Anthracobune? daviesi* Pilgrim, 1940, *in* Gingerich, 1977)
— *Pilgrimella pilgrimi* Dehm & Œttingen-Spielberg, 1958
(= *Anthracobune pilgrimi* (Dehm & Œttingen-Spielberg, 1958) West, 1983
— *Lammidhania wardi* (Pilgrim, 1940) Gingerich, 1977
(= Genus indet. (aff. *Anthracobune*) *wardi* Pilgrim, 1940)
(= *Pilgrimella wardi* (Pilgrim, 1940) Dehm & Œttingen-Spielberg, 1958)
— *Jozaria palustris* Wells & Gingerich, 1983

CETACEA

PROTOCETIDAE
— *Ichthyolestes pinfoldi* Dehm & Œttingen-Spielberg, 1958
— *Gandakasia potens* Dehm & Œttingen-Spielberg, 1958
— *Pakicetus inachus* Gingerich & Russell, 1981
— *Pakicetus attocki* (West, 1980) Gingerich & Russell, 1981
(= *Protocetus attocki* West, 1980)
— Protocetidae indet; opinion of Gingerich, pers. com., 1986.
(= Basilosauridae indet.; cited by West, 1980)

Lat. 29° 56′ N
Long. 70° 7′ E

PAKISTAN

PUNJAB PROVINCE

Dera Ghazi Khan District

Domanda Formation **middle Eocene**

Localities: Safed Tobah, Rakhi Nala, Mihal Nala

Pilgrim (1940) described an edentulous maxillary discovered by Pinfold some years earlier in the Sulaiman Range of central Pakistan, south of Fort Munro and near Safed Tobah. Additional collecting was done farther north by Pinfold at Rakhi Nala in 1943. In 1977 and 1981 University of Michigan — Geological Survey of Pakistan crews also collected at Rakhi Nala and Mihal Nala; cetacean material of considerable interest was obtained. A reconnaissance trip to the

96bis. This specimen may be from the overlying Murree Fm. (pers. com., Gringerich, 1987).

Source : MNHN, Paris

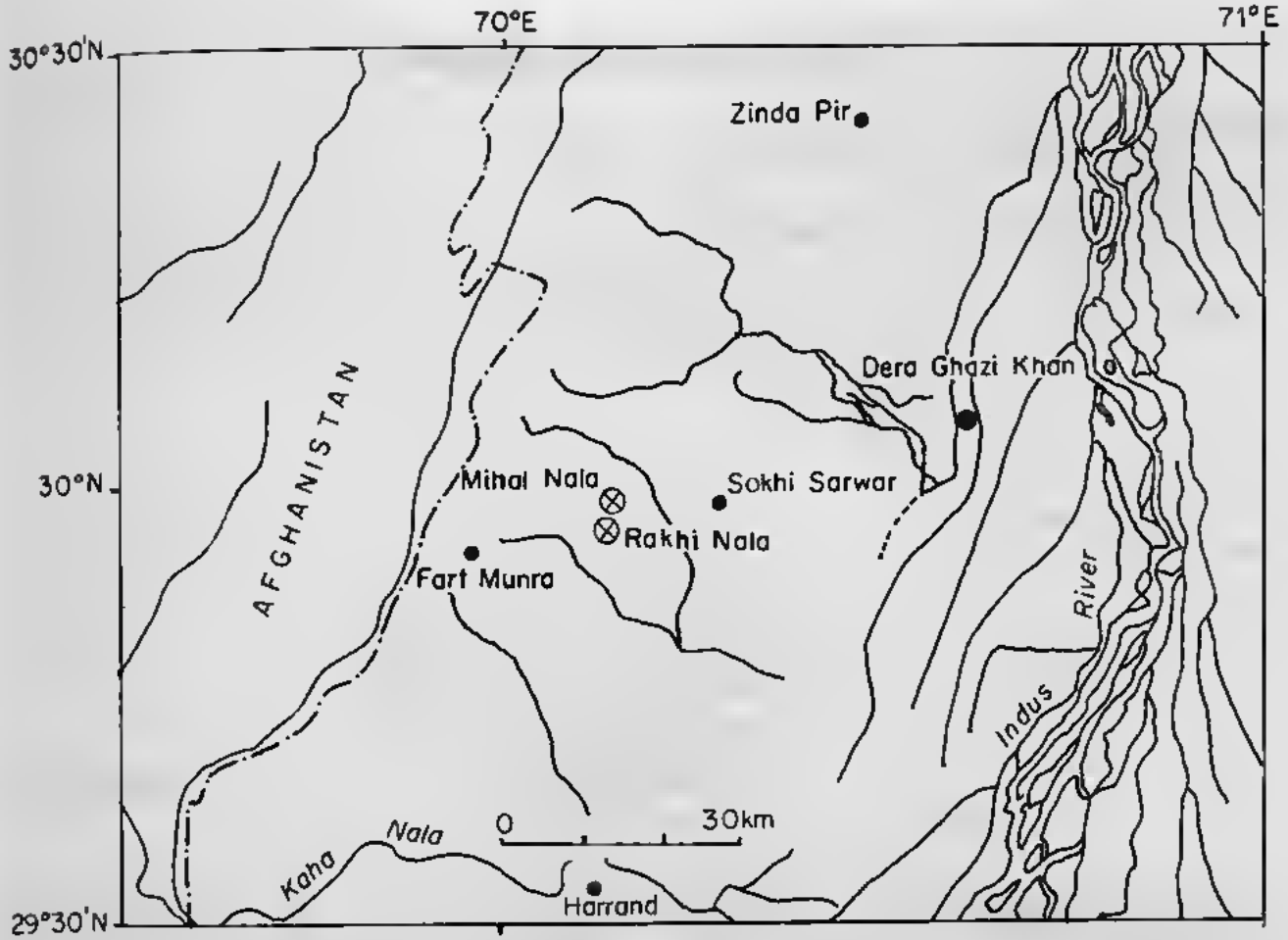


FIG. 81. — Map of the region west of Dera Ghazi Khan, Pakistan, showing the situation of the fossil mammal localities at Rakhi Nala and Mihal Nala. From field notes (Russell, 1977).

region of Safed Tobah in 1977 indicated that the Domanda Formation offers little probability of furnishing terrestrial mammalian fossils in that region. In general, the Domanda Formation appears to represent a shallow marine facies with rare and usually poorly preserved mammalian remains; only cetaceans have been identified.

In a measured section at Rakhi Nala the Domanda Formation is 297 m thick. It consists mainly of brown, greenish gray and chocolate colored claystone and silt; gypsiferous shales occur, as well as calcareous sandstone and limestone. It is overlain by the Pir Koh Limestone and underlain by the Habib Rahni Limes-

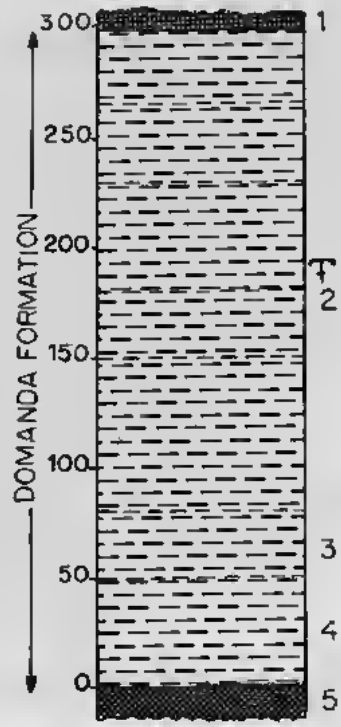


FIG. 82. — Measured stratigraphic section (297 m) of the Domanda Fm. at Rakhi Nala, Pakistan. 1. Pir Koh limestone and marl (white marl bed); 2. chocolate clays of the Domanda Fm.; 3. covered interval; 4. green clays of the Domanda Fm.; 5. transition zone with paper shale grading downward into the platey limestone of the Kohat Fm. Modified from Gingerich *et al.*, 1979.

Source : MNHN, Paris

Fauna of the Domanda Formation

ARTIODACTYLA?

ANTHRACOTHERIIDAE? indet.; cited by Pilgrim, 1940

CETACEA

— ARCHAEOCETI Indet., *in* Gingerich *et al.*, 1979a
(= Mesonychidae indet.; cited by Pilgrim, 1940)
(= *Gandaksia potens* Dehm & Œttingen-Spielberg, 1958; cited by Dehm & Œttingen-Spielberg, 1958, and by Szalay & Gould, 1966; denied by Gingerich, 1977)

— CETACEA Indet.; cited by Gingerich *et al*,. 1979a.

Lat. 45° 53′ N, approx.
Long. 80° 30′ E, approx.

Fig. 3, n° 5

USSR
KAZAKHSTAN SSR
Taldy-Kurgan Oblast

Kolpak[97] Svita **middle Eocene**
Locality: Shinzhaly

tone, formerly considered as part of the fossiliferous Khirthar Formation and now regarded as the top member of the Kohat Formation. It has been dated by invertebrate evidence as middle Eocene.

The Shinzhaly[98] locality was discovered by the geologist Didenko-Kislitsina in 1958 on the northern piedmont of the Dzhungarian[99] Alatau Range, about 7-8 km north of Andreyevka on the right bank of the Shinzhaly River. Kazakhstani paleontologists collected many fossil mammalian specimens, along with fish and turtle remains, from the variegated bentonitic clays at the site. Perissodactyls predominate in the assemblage, and of these most belong to *Eoletes*, but creodonts and rodents have been cited (Biryukov, 1972a). The lophialetid and deperetellid perissodactyls were briefly discussed by Didenko-Kislitsina (1965, 1976) and by Biryukov (1969). Although both *Schlosseria* and *Lophialetes* have been cited from this locality (Kozhamkulova and Orlovskaya, 1971; Biryukov, 1974), Reshetov (pers. com., 1981) is of the opinion that the material upon which these identifications were based is better referred to *Eoletes*. According to Kozhamkulova (1974), the remains of the artiodactyl she cited in 1969 belong to the genus *Archaeomeryx*, which signals its presence in the USSR for the first time.

Collections were made by the Paleozoological team of the Paleobiology Laboratory of the Academy of Sciences of the Kazakhstan SSR in 1964 and in 1966 to 1968 from the Eocene beds exposed along the Shinzhaly River.

Red colored calcareous clays, observable up to 35 m in thickness, overlie deposits of presumed Paleogene age. These clays form the nucleus of an anticlinal fold that is cut through by the valley of the Shinzhaly River to a depth of 22 m. The color here is brick red and raspberry red with greenish gray spots. Ostracods indicating a middle Eocene age have been found in these clays. They are overlain (on the south flank of the anticline) by light gray and rose-gray marls

97 Kolpak = a sort of fur hat.
98 Shinzaly (= Chinzhaly = Chinchily = Chindzhily = Chinjali) = a stream with warm water.
99 Dzhungaria is the Russian spelling; the Chinese prefer Junggar.

Source : MNHN, Paris

and also by brick red calcareous clays. Still higher stratigraphically are gray, greenish and red arenaceous clays, from which, in lenses of quartz sands, were collected ostracods, charophytes, mollusks and vertebrates (fish, turtles and mammals). A middle Eocene age has been proposed on the basis of this complex, although the presence of *Archaeomeryx* perhaps could be considered indicative of the late Eocene. *Rhodopagus* is also known from the middle Eocene site of Andarak. In conclusion, the mammalian fauna of Shinzhaly correlates adequately with the present concept of the Asian middle Eocene. Bazhanov *et al.*, 1971, however, remark that the charophytes from here indicate a late Eocene age.

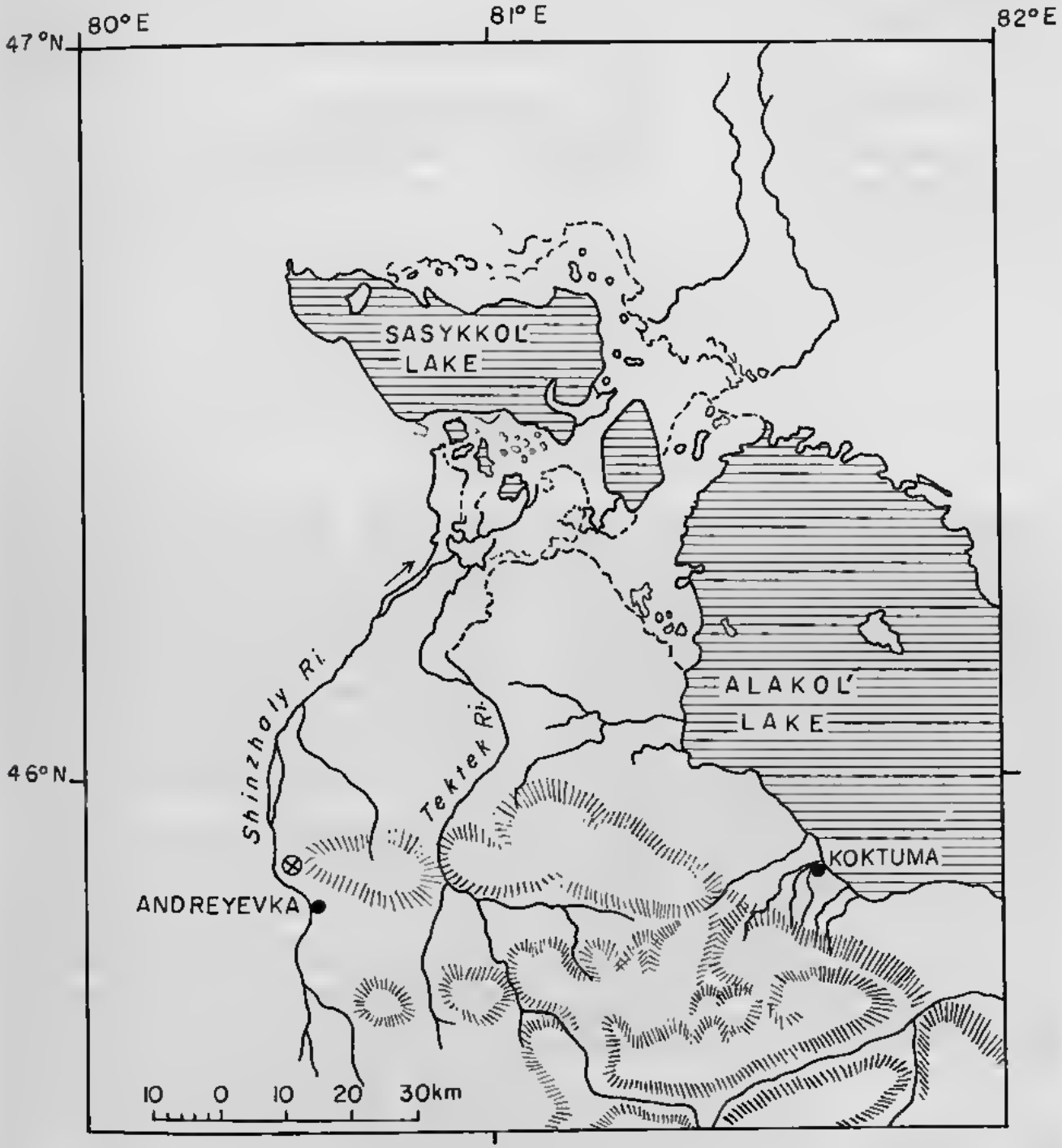


FIG. 83. — Detailed situation of the fossil locality of Shinzhaly on the northern edge of the Dzungharian Alatay Range, Kazakh S.S.R. Modified from a map provided by G. V. Shkurkin.

Source : MNHN, Paris

Fauna of Kolpak Svita at Shinzhali

LAGOMORPHA Indet.; cited by Badamgarav & Reshetov, 1976

RODENTIA Indet.; cited by Biryukov, 1972a

CREODONTA Indet.; cited by Biryukov, 1972a

PERISSODACTYLA

Brontotheriidae Indet.; cited by Biryukov, 1972a	
Deperetellidae	— *Teleolophus beliajevi* Biryukov, 1974b (= *Teleolophus beliajevi* Kozhamkulova & Orlovskaya, 1971, *nomen nudum*)
Lophialetidae	— *Eoletes gracilis* Biryukov, 1974
	— *Breviodon* sp.; cited by Biryukov, 1972a
Lophialetidae?	— *Rhodopagus* sp.; cited by Biryukov, 1972a
Hyracodontidae	— *Prohyracodon* sp.; cited by Reshetov, 1975

ARTIODACTYLA

Leptomerycidae	— *Archaeomeryx* sp.; cited by Kozhamkulova, 1974

U.S.S.R.

Kazakhstan

Zayzan Depression

Generalities

Perhaps nowhere in Asia within a restricted area is there a better sequence of continental Tertiary sediments than that found in the Zaysan Basin of eastern Kazakhstan. Although dating is still uncertain for some deposits in the lower part of the Tertiary section, it is possible that all the epochs from the late Cretaceous to the Quaternary are represented here. At least as concerns the Paleogene, the sequence is remarkably complete. The phenomenon responsible for this series of deposits was an embayment from a large lake that occupied the Dzungarian Depression, an area between the Mongolian Alatay Range to the north and the Tien Shan to the south, and whose approximate shores are still clearly visible in satellite photographs. Varying according to the fortunes of the lake, the Zaysan embayment formed a complex ensemble of late Cretaceous, Paleogene and Neogene sediments about 2,000 m thick, of which the Paleogene constitutes approximately 500 m.

Geologic study of this Paleogene began in 1883, while the first paleontologic discoveries were made only at the beginning of this century. Sporadic collecting continued, with particular activity in the 1950's and 60's, but it was the yearly expeditions and intensive work of the 1970's and 80's that have produced a true sequence of floras and faunas. The success of the latter joint expeditions has been due to the efforts of N. S. Shevyreva (of the Institut of Paleontology, Moscow) and V. M. Chkhikvadze (of the Institut of Paleobiology, Tbilisi). Stratigraphic control has been assured by the geologist B. A. Borisov (All-Union Geological Institute, Leningrad).

From a geological point of view the Zaysan Basin is relatively well known (Vasilenko, 1961; Borisov, 1963, 1967; Erofeyev, 1969; Tolstikova, 1976; Venus *et al.*, 1980). Research on its vertebrate fossils, however, has lagged behind and more material is still needed before a comprehensive analysis of the various faunas can be presented. Diverse biostratigraphic studies have been published recently on the Zaysan Paleogene, which reflect the state of present knowledge (Borisov, 1983, 1984; Gabunia, 1983, 1984; Gabunia *et al.*, 1983; Il'inskaya *et al.*, 1983).

The division of the Paleogene sediments in the

Source : MNHN, Paris

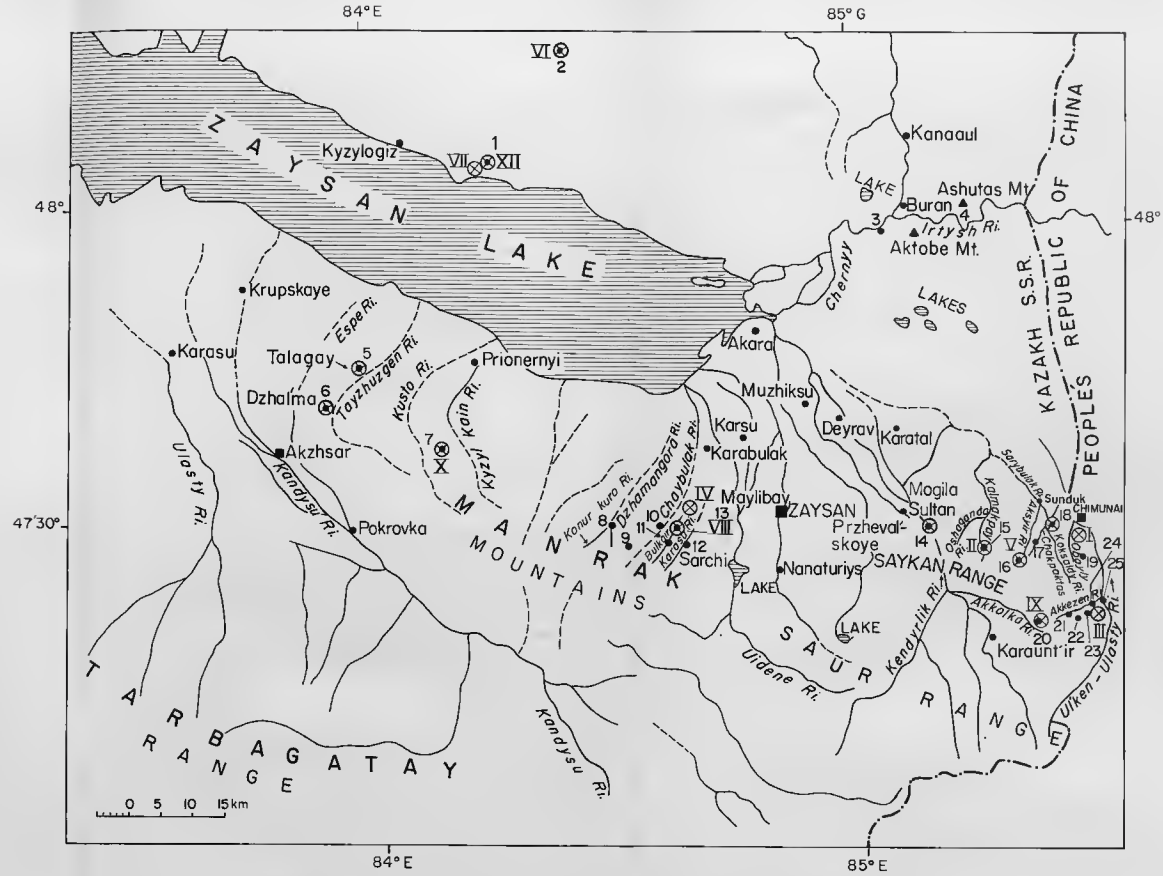


FIG. 84. — Sketch map of the Paleogene fossil localities of the Zaysan Depression, Kazakh S.S.R.; accuracy approximate. Roman numerals indicate areal sites; Arabic numerals are the points where the figured stratigraphic sections were taken. Modified from Vasilenko, 1961.

MUSEUM PARIS

Source : MNHN, Paris

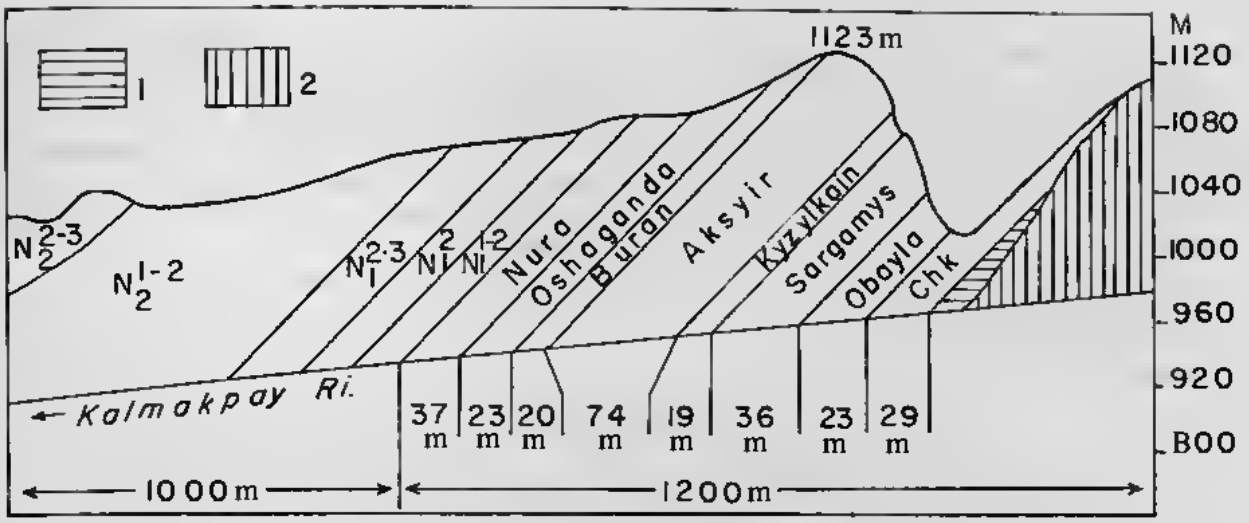


FIG. 85. — Diagrammatic cross section through Kalmakpay Mountain (Kazakh S.S.R.), paralleling the Kalmakpay River in Areal Site 11. In this sketch of the stratotype sequence the Paleogene svitas are named (Chk: Chakpaklas Svita) but not those of the Neogene. 1. Paleozoic rocks; 2. late Triassic conglomerate. The section is approximately from north to south (at right). Modified from Borisov, 1963.

Zaysan Basin has been treated in different fashions by various authors, but the succession itself of the identified beds is not questioned. The system used here is that proposed and explained in detail by Borisov, 1963; this concept was confirmed by the Interdepartmental Stratigraphic Committee of the U.S.S.R. in 1981. According to Borisov's scheme the Paleogene is subdivided into 14 svitas, most which can be observed in the stratotype section established on the right bank of the Kalmakpay River in the southeastern part of the Zaysan Basin (the Kusto, Chaybulak and Konurkura Svitas are absent).

Paleocene sediments have been found only in the northern part of the basin. They are from 85-120 m thick and discordantly on Palaeozoic or late Cretaceous deposits. The three svitas recognized are the following (from the top to bottom):

3. the Kiinkerish[100] Svita: essentially sands and silts;
2. the Dyusyumbay[101] Svita: sands, sometimes with sandstone in the lower part and with clays in the upper part;
1. the Aktobe[102] Svita: clays and silts with intercalations of sandstone in the lower part.

Outcrops of these svitas are usually white, gray or red. Among the clay minerals kaolinite and montmorillonite predominate; the sands are mostly quartzitic. The majority of these beds, as well as those higher in the section, bear signs of alteration or erosion due to regression of the lake water in the Zaysan embayment. Mammalian remains have not yet been discovered in these three units. The Kiinkerish and Dyusyumbay Svitas have been referred to the Paleocene on the basis of spores, pollen and leaf impressions. The age of the Aktobe Svita was determined by its stratigraphic position, by leaf impressions and by mollusks. The Paleocene svitas are separated by erosional surfaces.

The sequence of Eocene and Oligocene svitas in the Zaysan Basin is as follows (from top to bottom):

LATE OLIGOCENE
Nura
Oshaganda

MIDDLE OLIGOCENE
Buran

EARLY OLIGOCENE
Kusto
upper Aksyir subsvita
middle Aksyir subsvita

100 Kiinkerish = revenging battle.
101 Dyusyumbay = bay (title of an important person); dyusyuum (meaning profit, given as a proper name).
102 Aktobe = white hill.

Source : MNHN, Paris

LATE EOCENE
lower Aksyir subsvita
Kyzylkain
Chaybulak

MIDDLE EOCENE
Konurkura
Sargamys
upper Obayla subsvita
middle Obayla subsvita
lower Obayla subsvita
Chakpaktas

The principal Zaysan Paleogene localities have been grouped by Soviet workers in a series of areas distinguished by Roman numerals I-XII (but number VII and most of XII (Chakel'mes) north of the lake concern only Neogene sediments); usually these are identified by the name of the river that has exposed the fossiliferous levels.

List of localities included within each areal site

I. OBAYLA River
middle part of Obayla Svita — Maykapchigay

II. KALMAKPAY River
middle part of Obayla Svita — Kalmakpay
Chapaktas Svita — Mozhzhevel'nik, Stenka (referred to as areal site XI by Soviet workers)

III. UL'KEN-ULASTY River
lower part of Obayla Svita — Prirechnoye

IV. CHAYBULAK River
middle part of Obayla Svita — Osobaya Sopka
— Belaya Banka
lower part of Obayla Svita — Chernaya Banka

V. AKSYIR River
Nura Svita — Nad Rodnikom
(no Oshaganda Svita locs.)
Buran Svita — I Yuzhnaya Kuesta I Antiklinali-Raskop
(no Kusto Svita locs.)
upper part of Aksyir Svita — tam zhe, Uroven', 82-84
— tam zhe, Uroven', 55-56
— tam zhe, Uroven', 52
— tam zhe, Uroven', 47-49
— I Yuzhnaya Kuesta I Antiklinali-Uroven', 36-37
— Pyat Kameney
lower part of Aksyir Svita — Rodnik
— Podnozhiye I Severnoi Kuesty I Antiklinali-Techka I (= Severnaya I)
— tam zhe, Tochka IA (= Severnaya IA)
— Tagvi
Kyzylkain Svita — Podnozhiye I Sovernoi Kuesty I antiklinali
— "Zheltye Pyatna"
(no Chaybulak Svita locs.)
(no Konurkura Svita locs.)
Sargamys Svita — Vyshe Fermy (= Verkhniy)
— Zhumyrtka
— Bulat
upper part of Ohayla svita — Chernyy Trioniks
lower part of Obayla svita — Yadro Antiklinali

Source : MNHN, Paris

VI. KIIN-KERISH

Kusto Svita	— Kiin-Kerish III
upper part of Aksyir Svita	— Lager' Biryukova; Kiin-Kerish II
lower part of Aksyir Svita	— Kiin-Kerish I

VIII. BULKAIR

upper part of Aksyir Svita	— Chernyy Kamen'
	— Grib
	— Bublik
middle part of Aksyir Svita	— Cherep
Konurkura Svita	— Sopka Otpetchotok

IX. AKKOLKA

upper part of Aksyir Svita	— Akkolka
lower part of Aksyir Svita	— Ovrag Korzhumbay

X. MEZHDURECHYE KUSTO-KYZYLKAIN (region between the Kusto and Kyzylkain Rivers)

Nura Svita	— Shatrovaya Sopka
(no Oshaganda Svita locs.)	
(no Buran Svita locs.)	
Kusto Svita	— Lysaya Sopka (= Plesh)

XII. CHAKEL'MES

Kusto Svita

For some time certain Soviet geologists were skeptical of the value of vertebrate fossils as dependable indicators of age. This was occasioned in the Zaysan Basin by the discovery (in the 1960's by Y. Tsekhovsky) in the Konurkura Svita at Sopka Otpechotok, of material that was considered to represent the imprint of dinosaur skin. As the Konurkura was regarded as Tertiary on other evidence, the doubt was understandable. Later, the fossil was determined as that of a turtle. The locality of Sopka Otpechotok is situated between the Konurkura and Dzhamangora Rivers; no mammals have as yet been found in the Konurkura Svita.

U.S.S.R.

KAZAKH S.S.R.

Zaysan Depression

Chakpaktas Svita **middle Eocene**

Localities: Areal Site II, Kalmakpay River (Mozhzhevel'nik 2, 3 and 4; Stenka and Sloyenka)

The oldest mammalian assemblage found to date in the Zaysan Basin is that from the Chakpaktas Svita[103]. It crops out extensively in the northern foot hills of the Saykan Range and is characterized by sands in the lower and clays in the middle and upper parts. The Chakpaktas Svita unconformably overlies Mesozoic or Paleozoic sediments at Kalmakpay[104] and is also separated from the overlying Obayla Svita by an unconformity.

Several fossiliferous levels were discovered in the Chakpaktas Svita on the right bank of the Kalmakpay River in 1980 by Chkhikvadze, but vertebrate bones at the site were noted as early as 1963 by Borisov. In the Kalmakpay section the Chakpaktas Svita is situated at the base of about 260 m of Eocene and Oligocene sediments, at a distance of 300-350 m from the river and 140 to 160 m above it. According to recent data (Borisov, 1984) it is 24 m thick and is separated from

103 Chakpaktas = flint.
104 Kalmakpay = an important Kalmuk person.

Source : MNHN, Paris

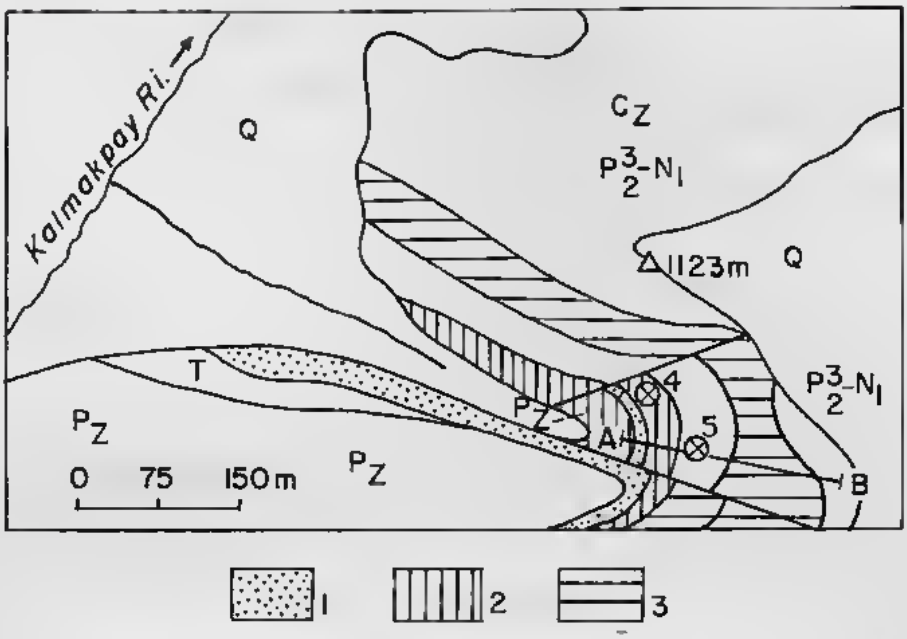


FIG. 86. — Sketch map of the southern part of Kalmakpay Mountain, Kazakh S.S.R. This area has been called Areal Site XI (here combined with areal Site II) and principally concerns localities 4 (the Chakpaktas sites of Mozhzhevel'nik 1 to 4, Stenka and Sloyenka) and 5 (site called Kalmakpay, in the Obayla Svita). 1. late Cretaceous sediments; 2. Chakpaktas Svita; 3. Sargamys Svita; Cz: locality in the Buran Svita where the type of *Cadurcodon zaisanensis* was found. Modified from Borisov, 1984

the overlying Obayla Svita by a surface of erosion. The underlying 5 to 5.5 m sands and pebbles that Borisov (1963) regarded as the basal part of the Chakpaktas Svita have been shown to be referable to the late Cretaceous (Minina and Borisov, 1969).

Vertebrate remains are found in brownish red clays and in sands. The locality of Mozhzevel'nik [105] 1 is from 3 to 4.5 m from the base of the section; Mozhzhevel'nik 2 is 7-12 m above the base, Mozhzevel'nik 3 is 12-15 m, Mozhzevel'nik 4 is 15 - 15.5 m, Stenka [106] is 15.5 - 19.5 and Sloyenka is 19.5 - 20.5 m from the base. No mammals are yet known from Mozhzhevel'nik 1 and a few have been found at Mozhzhevel'nik 2 and 4, but Mozhzhevel'nik 3 is quite productive and has furnished excellently preserved specimens. Sloyenka is principally a floral locality,

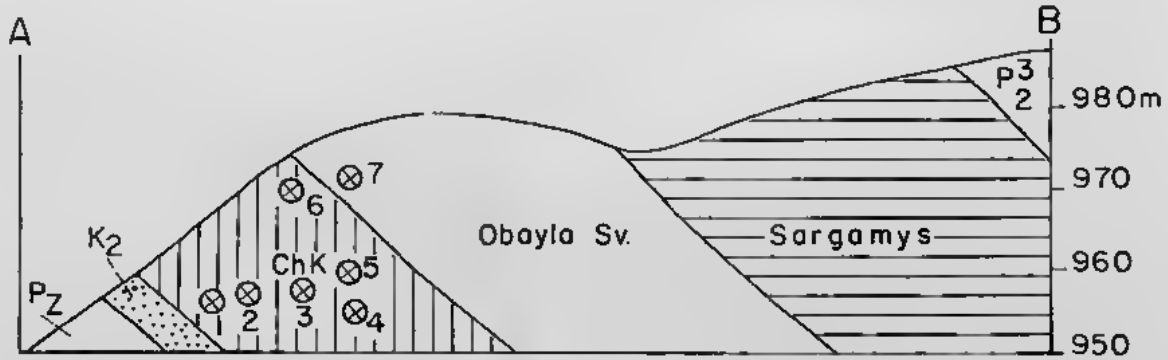


FIG. 87. Diagrammatic cross section through the southern part of Kalmakpay Mountain, Kazakh S.S.R. Same legend as above, except for the numbered localities. 1 through 4 = Mozhzhevel'nik 1 through 4; 5. Stenka; 6. Sloyenka; 7. site called Kalmakpay in the Obayla Svita; Chk: Chakpaktas Svita. Modified from Borisov, 1984.

105 Mozhzhevel'nik = juniper bush.
106 Stenka = wall.

Source : MNHN, Paris

but fragments of indeterminable fossil mammalian bones have been collected there. Areal Site XI was proposed for the Chakpaktas localities, but it is here grouped under Areal Site II.

The age of the svita was determined in large part by the mammalian fossils it contains, which Soviet workers consider to be early Eocene; one form, cf. *Homogalax*, could indicate an early Eocene fauna, but other genera, such as *Helaletes*, *Rhodopagus* and *Triglopus*, suggests a middle Eocene age.

Fauna of the Chakpaktas Svita

(furnished by Prof. Gabunia)

RODENTIA

Ctenodactylidae — *Saykanomys* sp.; cited by Gabunia, 1984

CARNIVORA

Miacidae — cf. *Miacis* sp.; cited by Gabunia, 1983

PERISSODACTYLA

Isectolophidae — cf. *Homogalax* sp.; cited by Gabunia, 1984

Helaletidae — *Helaletes* n. sp.; cited by Gabunia, 1984
— Helaletidae indet.; cited by Gabunia, 1984

Lophialetidae?[107] — *Rhodopagus* aff. *minutissimus* Reshetov, 1979; cited by Gabunia, 1984
— *Rhodopagus* sp.; cited by Gabunia, pers. com., 1982

Hyracodontidae — *Triplopus* sp.; cited by Gabunia, 1984

Perissodactyla Indet., cf. Hippomorpha; cited by Gabunia, pers. com., 1982

ARTIODACTYLA

Dichobunidae n. gen., n. sp.; cited by Gabunia, 1984

U.S.S.R.
Kazakhstan S.S.R.
Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Lower Obayla Subsvita **middle Eocene**

Localities: Areal Site III, Ul'ken-Ulasty River (Prirechnoye); Areal Site IV, Chaybulak River (Chernaya Banka); Areal Site V, Aksyir River (Yadro)

The mammalian fossils from the lower part of the Obayla Svita were discovered by Chkhikvadze and Shevyreva in the valleys of the rivers Chaybulak, Aksyir and Ul'ken-Ulasty in the 1960's and 70's. Crocodiles, turtles, fish and mollusks, however, were cited by Borisov in 1963.

On the right bank of the Chaybulak[108] River, near the foot hills northeast of the Manrak Range, brown clays of the Obayla Svita constitute the Chernaya Banka[109] locality, an isolated hillock 5 m in height and 15 m wide at the base. Here the svita overlies late Cretaceous deposits which form a sort of pedestal for the hillock. On the left bank of the Chaybulak River the Obayla Svita is overlain (with disconformity) by the

107 Lucas & Schoch (1981) referred this genus to the Hyracodontidae; Radinsky (pers. com., 1984) denies this assignment.
108 Chaybulak = stream source.
109 Chernaya Banka = black bank.

Source : MNHN, Paris

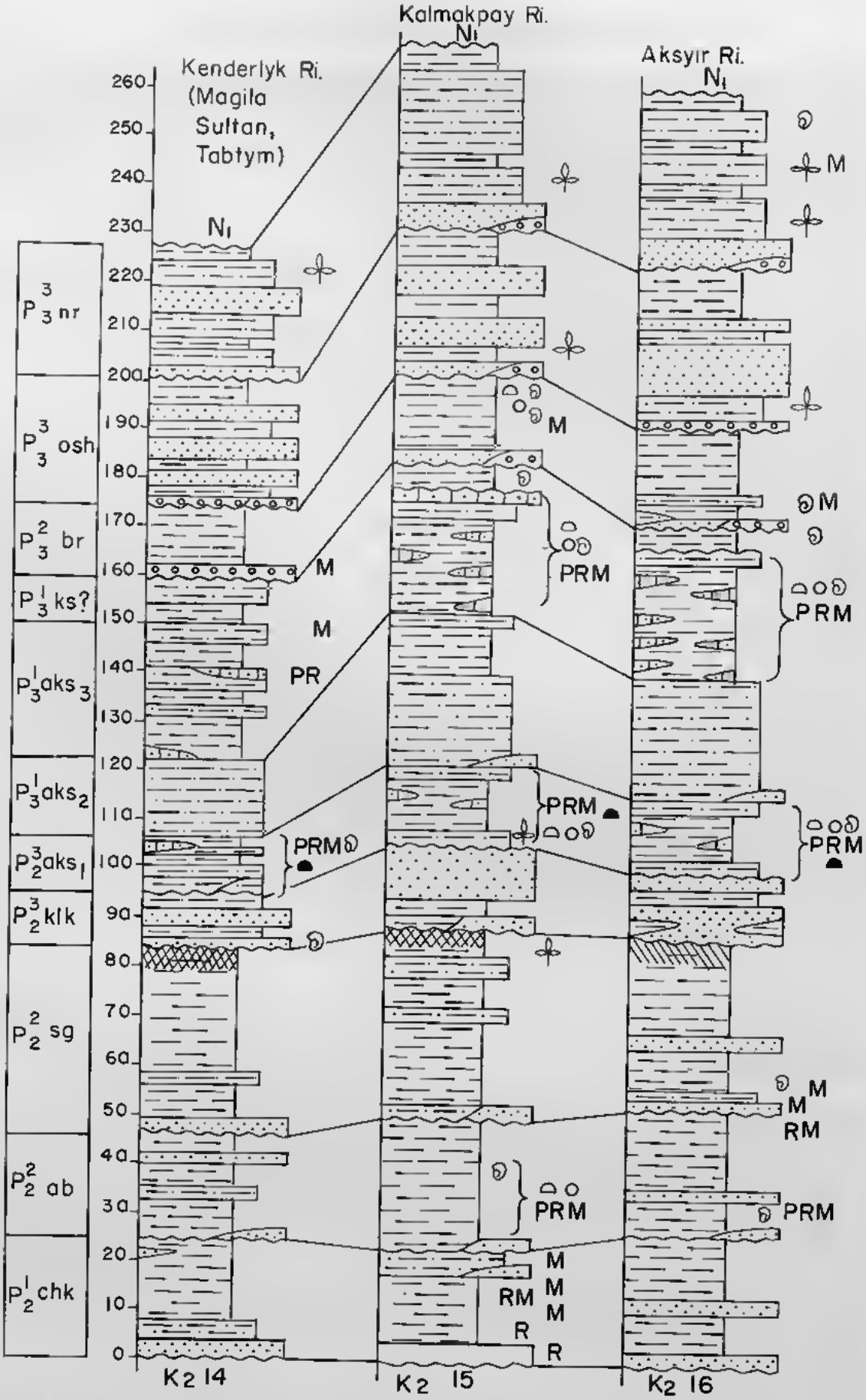


FIG. 88. - Stratigraphic sections in the southeastern part of the Zaysan Depression, Kazakh S.S.R., on the Kenderlyk, Kalmakpay and Aksyir rivers. For legends, see Fig. 97. Modified from a drawing provided by B. A. Borisov.

Source : MNHN, Paris

Sargamys Svita. In this river valley the Obayla Svita does not seem to exceed 20-25 m. In the Chernaya Banka hillock the Obayla Svita is nearly horizontal. Two levels containing vertebrates have been noted in the section: one at 2.5 m from the base and the other near the summit. The name of the locality comes from a concentration of dark colored mollusks on top of the hillock (black bank, or shoal).

On the right bank of the Aksyir River the

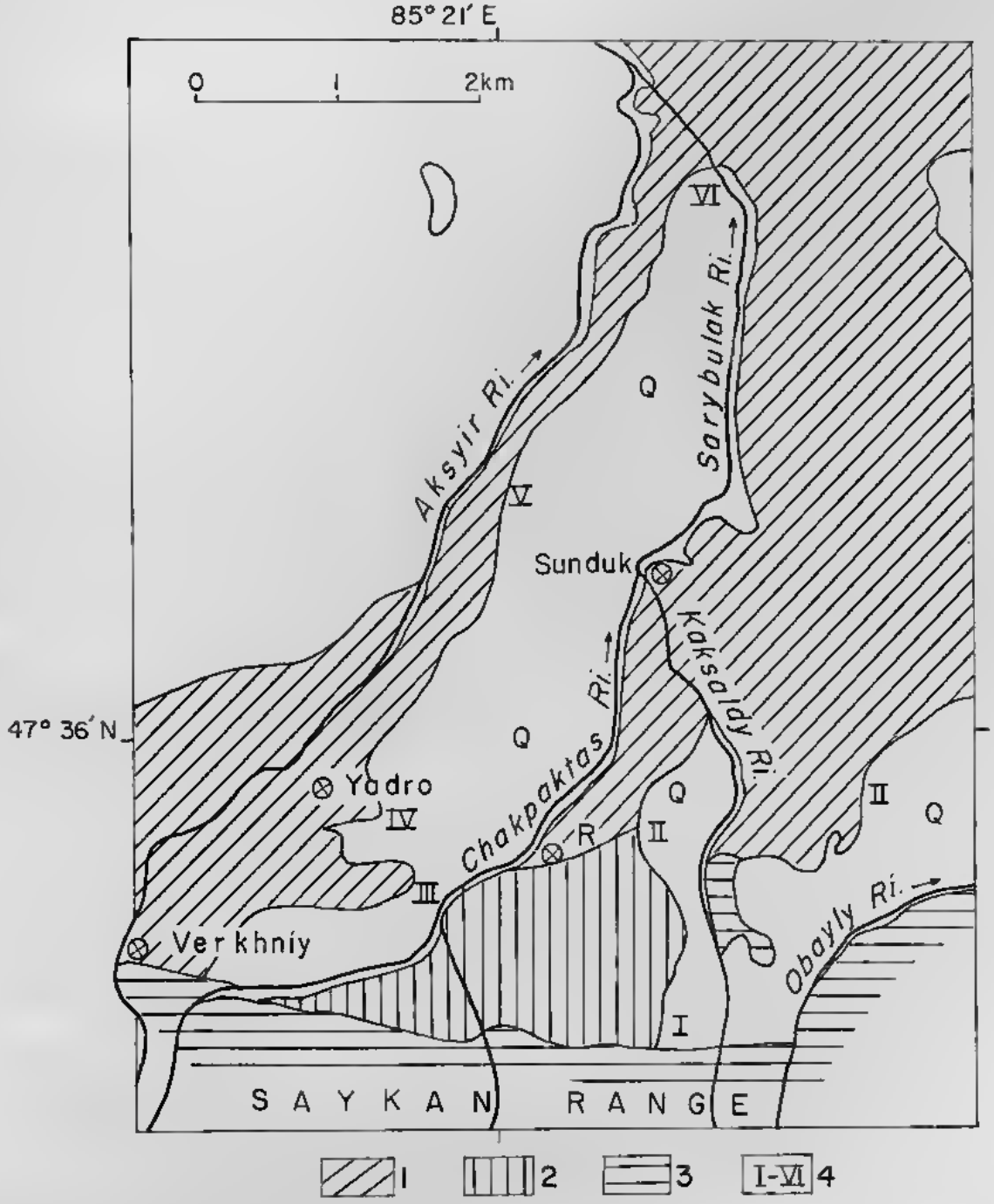


FIG. 89. — Sketch map of the region around Areal site V on the Aksyir River, one of the most important in the eastern part of the Zaysan Basin, Kazakh S.S.R.; Yadro is centrally located in this site. R indicates a locality in the Buran Svita that furnished rhinocerotoid remains. 1. Tertiary sediments; 2. Mesozoic; 3. Paleozoic; 4. I to VI are situated at the axes of the series of anticlines that were produced north of the Saykan Range and cut through by the Aksyir River. Modified from Vasilenko, 1961.

Source : MNHN, Paris

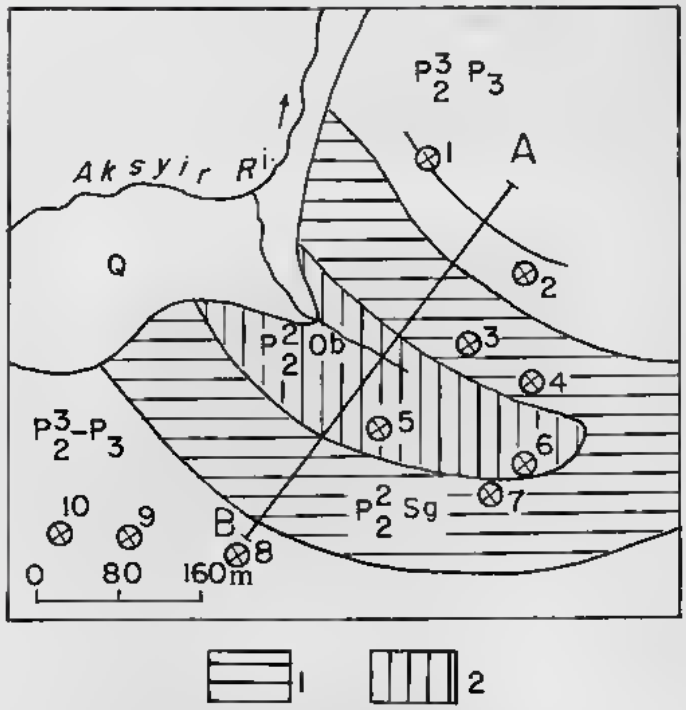


FIG. 90. — Detailed sketch map of the central part of Areal Site V on the Aksyir River, Kazakh S.S.R. 1. Sargamys Svita; 2. Obayla Svita. Locality numbers: 1 Severnaya Cuesta (several localities occur along the length of the Cuesta, including Tagvi (lower part of the Aksyir Svita); 2. Zhaltye Pyatna (Kyzylkain Svita); 3. Bulat; 4. Kolyuchka; 5. Yadro; 6. Chernyy Trioniks (upper part of the Obayla Svita); 7. Zhumyrtka; 8. Pyal Kameney (upper part of the Aksyir Svita); 9. Raskop (Buran Svita); 10. Rodnik (Nura Svita). Modified from Borisov, 1984.

brown clays of the Obayla Svita crop out in the axis (or nucleus) of the first Aksyir anticline, hence the name of the mammal locality, Yadro [110]. The fossiliferous levels lie in the lowest part of the svita, which is here 20-25 m thick. The contact with the underlying Chakpaktas Svita has not been observed; the Sargamys Svita is unconformably overlying, and farther up the section follow the svitas of the late Eocene and Oligocene.

The Kenderlyk Basin is a small structural feature south of, but near the eastern part of the Saykan Range. The Akkolka and Akkezen Rivers flow through it (in opposite directions). Close to the junction of the latter with the Ul'ken-Ulasty River is the locality Prirechnoye in Areal Site III. It is situated on the left bank of the Ul'ken-Ulasty River, which forms the boundary between the Soviet Union and China. Also in the brown clays of the Obayla Svita, near the mouth of the Akkezen River, fossil mammals were found. The Obayla Svita is nearly horizontal here, overlying the Paleozoic. It is 5 m thick and is overlain disconformably by the Sargamys Svita. Mammalian remains have been noted throughout the lower part of the Obayla Svita; the middle and upper parts are absent in this region.

Soviet workers have placed this locality in the early Eocene but there is little justification for this assignment, based on the known mammalian assemblage.

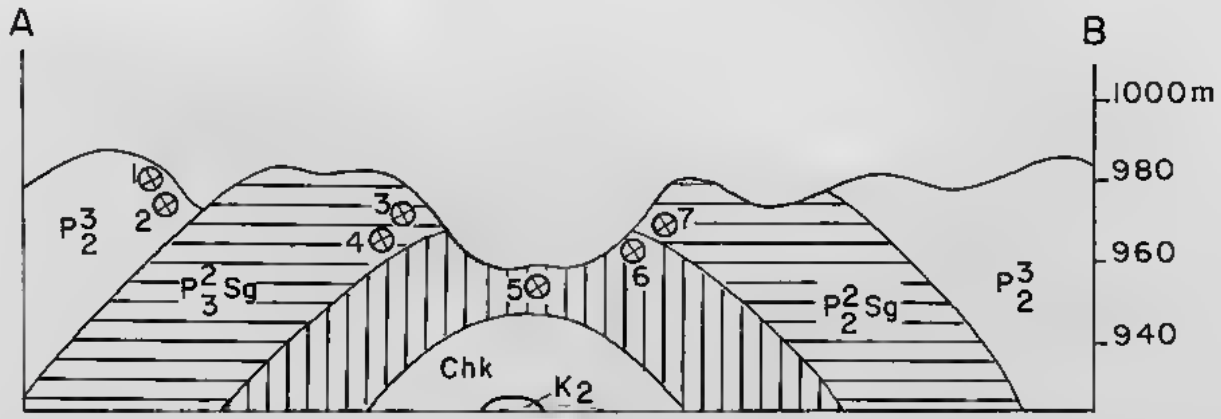


FIG. 91. — Diagrammatic cross section through the central part of Areal Site V on the Aksyir River, Kazakh S.S.R. Same legend as for Fig. 90. Chk: Chakpaktas Svita; K2: late Cretaceous. Modified from Borisov, 1984.

110 Yadro = nucleus.

Source : MNHN, Paris

Fauna of the Lower Obayla Subsvita

(furnished by Dr. Shevyreva, Dr. Gureyev and Prof. Gabunia)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

PANTODONTA Indet.; cited by Gabunia, 1977

LAGOMORPHA

LEPORIDAE — *Shamolagus ninae* Gabunia, 1984

RODENTIA

PARAMYIDAE — *Abrosomys agasma* Shevyreva, 1984
— *Paramys obaylensis* Shevyreva, 1984
— Paramyidae? indet.; cited by Shevyreva, pers.com., 1981

CTENODACTYLIDAE [111] — *Tamquammys tantillus* Shevyreva, 1971a
— *Saykanomys chalchae* Shevyreva, 1976
(= *Saykanomys chalchis* Shevyreva, 1972) (probably a junior synonym of *Advenimus bohlini* Dawson, 1964, according to Dawson *et al.*, 1984)
— *Chkhikvadzomys elpisma* Shevyreva, 1984
— *Bolosomys brachybamon* Shevyreva, 1984
— *Geitonomys bouvites* Shevyreva, 1984
— "Chapattimyidae" indet.; cited by Shevyreva, pers. com., 1981
— *Petrokozlovia notos* Shevyreva, 1972

PHIOMYDAE? — *Bleutosomys dasikerkos* Shevyreva, 1984

MYOMORPHA
Family Ident. — *Aksyiromys dalos* Shevyreva, 1984
— *Ulkenulastomys abrotos* Shevyreva, 1984

CARNIVORA

cf. MIACIDAE Indet.; cited by Gabunia, pers. com., 1981

CREODONTA

HYAENODONTIDAE — cf. Proviverrinae indet.; cited by Gabunia, pers. com., 1981

CONDYLARTHRA? Indet.; cited by Gabunia, pers. com., 1982

PERISSODACTYLA

BRONTOTHERIIDAE — *Palaeosyops* sp.; cited by Gabunia, 1977

ISECTOLOPHIDAE Indet.; cited by Gabunia, 1977

HELALETIDAE Indet.; cited by Gabunia, 1984

LOPHIALETIDAE — *Breviodon* cf. *minutus* (Matthew & Granger, 1925f) Reshetov, 1975; cited by Gabunia, 1982

LOPHIALETIDAE? — *Rhodopagus* cf. *minutissimus* Reshetov, 1979; cited by Gabunia, 1982
(= *Rhodopagus leonardi* Gabunia, 1977, *nomen nudum*)
— *Rhodopagus* cf. *pygmaeus* Radinsky, 1965; cited by Gabunia, 1977
— cf. *Rhodopagus* sp.; cited by Gabunia, pers. com., 1982

HYRACODONTIDAE — *Triplopus* sp.; cited by Gabunia, 1977

RHINOCEROTOIDEA Indet. — *Caenolophus* sp.; cited by Gabunia, 1977
— cf. *Caenolophus* sp.; cited by Gabunia, pers. com., 1982

ARTIODACTYLA

DICHOBUNIDAE Indet.; cited by Gabunia, 1977

Family indet. — *Aksyiria oligostus* Gabunia, 1973
— *Paraphenacodus solivagus* Gabunia, 1971

111 See footnote n° 33, p. 88.

Source : MNHN, Paris

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Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Middle Obayla Subsvita **middle Eocene**

Localities: Areal Site I, Obayla River; Areal Site II, Kalmakpay River; Areal Site IV, Chaybulak River (Osobaya Sopka and Belaya Banka)

Mammalian fossils were discovered in the middle Obayla Subsvita by Borisov in 1960 in the Kalmakpay and Obayla River valleys. Later, they were also found in the Chaybulak River basin at Osobaya Sopka by Zhegallo early in the 1960's and at Belaya Banka by Chkhikvadze and Shevyreva in the 1960's and 70's. The two latter localities added greatly to the previous knowledge of the vertebrates from this part of the svita.

Osobaya Sopka [112] is situated upstream on one of the left tributaries of the Chaybulak River. This hillock (sopka in Russian), 50 m long and 15 m high, is made up of the Obayla, Sargamys and Konurkura Svitas, which dip gently to the north. The visible thickness of the Obayla Svita is about 7 m. Its upper part is probably missing due to a period of erosion, while the lower part, cropping out nearby on late Cretaceous rocks, does not appear here. Fossils of mammals were found principally in the sands which lie 3.5 m below the summit of the svita.

Belaya Banka hillock [113] is 120 m northwest of Chernaya Banka (in the lower part of the Obayla Svita). It is 10 m high, from the bottom of the gully, and 40 m long and is made up of the clays that constitute the middle part of the Obayla

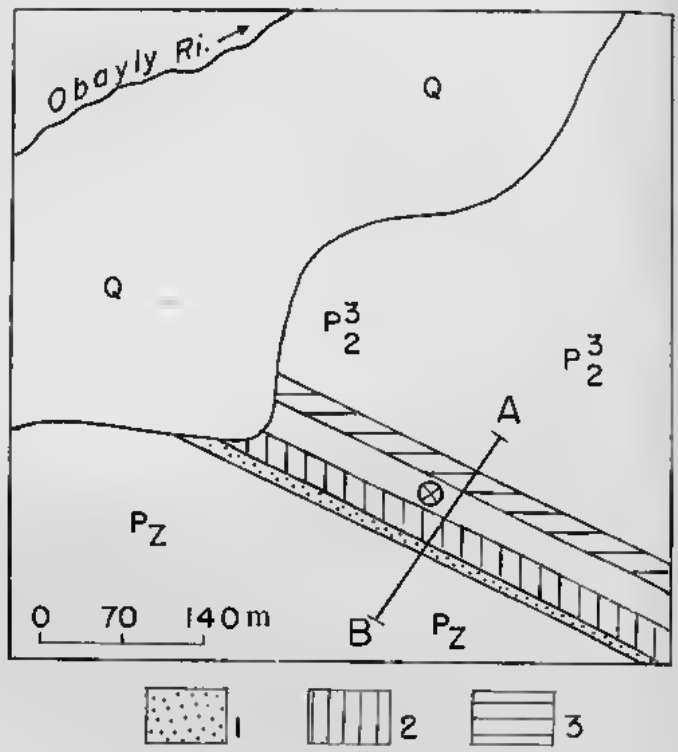

FIG. 92. — Sketch map of Areal Site I on the Obayly River, Kazakh S.S.R.. The fossil locality indicated is Maykapchigay in the Obayla Svita. 1. late Cretaceous sediments; 2. Chakpaktas Svita; 3. Sargamys Svita. Modified from Borisov, 1984.

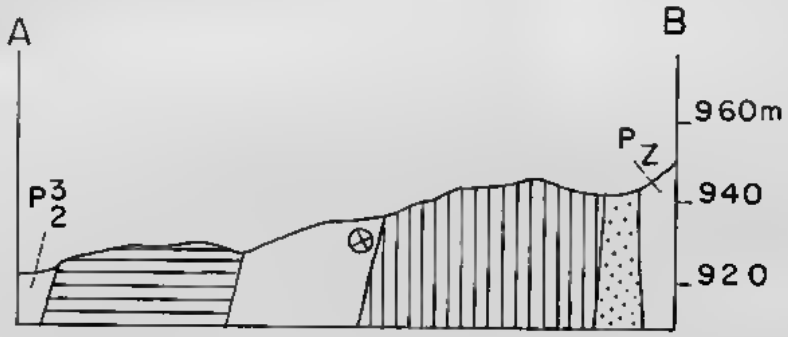

FIG. 93. — Diagrammatic cross section through Areal Site I on the Obayly River, Kazakh S.S.R. Same legend as for Fig. 92. Modified from Borisov, 1984.

112 Osobaya Sopka = isolated hillock.
113 Belaya Banka = white bank.

Source : MNHN, Paris

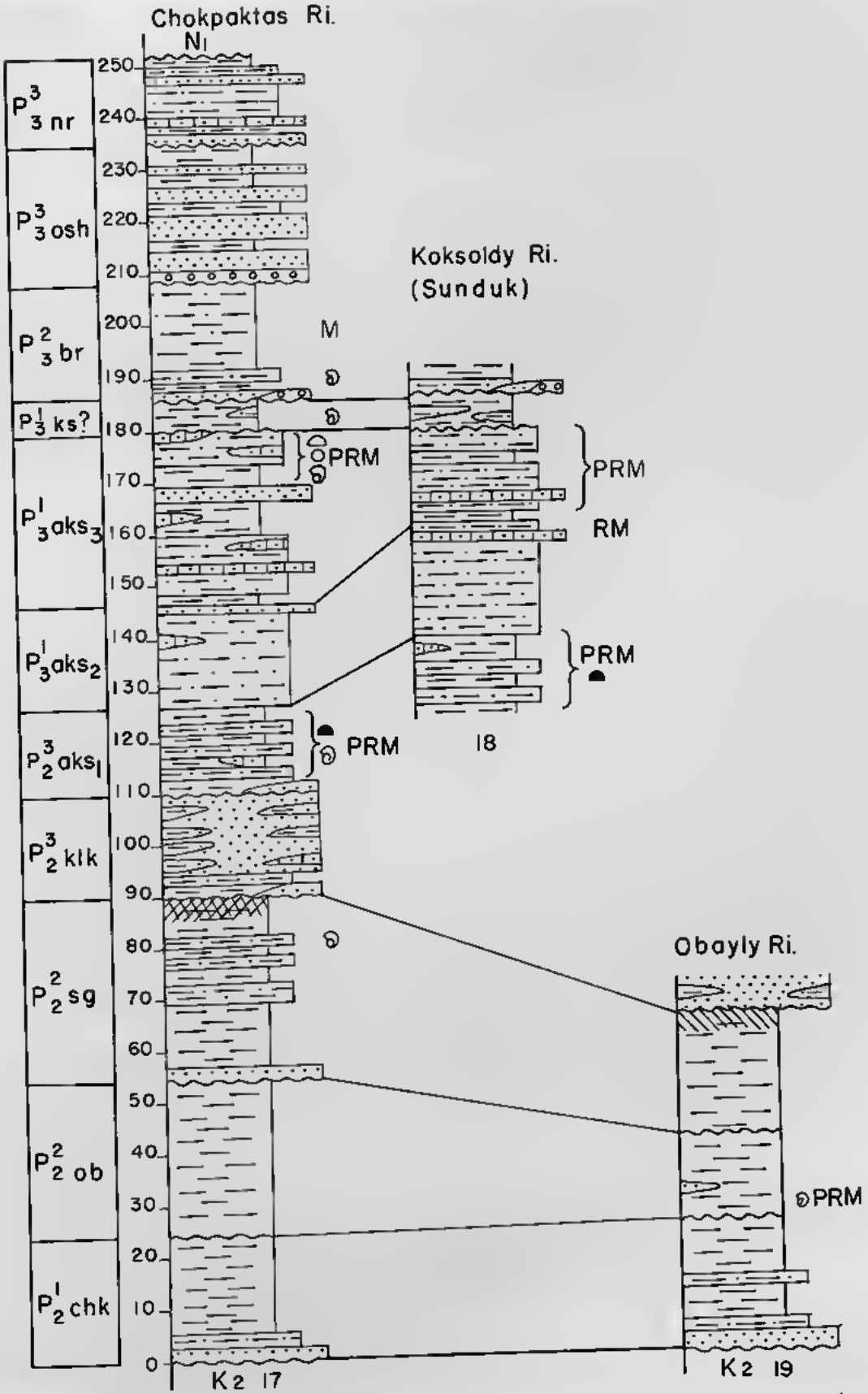

FIG. 94 Stratigraphic sections in the southeastern part of the Zaysan Depression, Kazakh S.S.R., on the Chakpaktas, Koksaldy and Obayly Rivers. For legends, see Fig. 97. Modified from a drawing provided by B. A. Borisov.

Source : MNHN, Paris

Svita. In this area the lower part of the Obayla Svita does not crop out. At the base of the hillock are concentrations of light colored mollusk shells (which are responsible for its name, white) and higher up are two levels containing mammalian fossils.

On the right bank of the Kalmakpay River the Obayla Svita has a thickness of about 28 m and dips steeply to the northeast. It is essentially made up of brown clays and underlies the Sargamys Svita; it is separated from the underlying Chakpaktas Svita by unconformity and by a meter-thick sandy bed. The collections of mammals and other vertebrates were made in the interval of 4 to 7.5 m from the base of the svita.

In the northern foot hills of the Saykan Range, on the right bank of the Obayly River, one of the low crests (10 - 15 m high) is composed of a series of vertical beds extending from the late Cretaceous through the Chakpaktas, Obayla, Sargamys, Kyzylkain and Aksyir Svitas. The Obayla Svita is 17 m thick and the fossiliferous level is located 2 m from the base. The locality itself is about 5 km south of the village of Maykapchigay[114].

Freshwater mollusks, fish and abundant turtle and crocodile remains have been collected from the Obayla Svita, along with relatively few mammals; smaller forms of the latter predominate as material referable to large species is rare.

In comparison with Chinese and Mongolian faunas, the mammals of the middle part of the Obayla Svita represent a homogeneous assemblage clearly referable to a middle Eocene age.

Fauna of the middle Obayla Subsvita

(furnished by Dr. Shevyreva and Prof. Gabunia)

PANTODONTA

Coryphodontidae — *Eudinoceras obailiensis* Gabunia, 1961

DINOCERATA

Uintatheriidae Ident.; cited by Gabunia, 1977

RODENTIA

Ctenodactylidae[115] — *Tamquammys tantillus* Shevyreva, 1971a; cited by Shevyreva, 1983

Eomyidae Indet.; cited by Shevyreva, pers. com., 1981

CARNIVORA

Miacidae — cf. *Vulpavus* sp.; cited by Gabunia, pers. com., 1981

PERISSODACTYLA

Deperetellidae — *Teleolophus* cf. *medius* Matthew & Granger, 1925f; cited by Gabunia, 1977
— Deperetellidae Indet.; cited by Gabunia, pers. com., 1981

Helaletidae — *Veragromovia desmatotheroides* Gabunia, 1961
(= *Helaletes? desmatotheroides* (Gabunia, 1961) Radinsky, 1965)
(= *Helaletes desmatotheroides* (Gabunia, 1961) Dashzeveg, 1985
— cf. *Veragromovia* sp.; cited by Gabunia, pers. com., 1981
— *Helaletes*, cf. *mongoliensis* (Osborn, 1923a) Radinsky, 1965; cited by Gabunia, 1977

Lophialetidae — *Lophialetes* sp.; cited by Gabunia, pers. com., 1980
(= *Lophialetes minor* Gabunia, 1977, *nomen nudum*)
— *Lophialetes* cf. *expeditus* Matthew & Granger, 1925f; cited by Gabunia, 1977

114 Maykapchigay = deep, narrow valley with ("may") grease or tar (= Chimunai, name of that part of the village situated across the border in Xinjiang, People's Republic of China).

115 See footnote n° 33, p. 88.

Source : MNHN, Paris

LOPHIALETIDAE? — *Rhodopagus* sp.; cited by Reshetov, 1979

HYRACODONTIDAE — *Triplopus* cf. *implicatus* (Cope, 1873); cited by Gabunia, 1977
— *Forstercooperia* cf. *grandis* (Peterson, 1919) Radinsky, 1967; cited by Gabunia, pers. com., 1981
— *Prohyracodon robustus*, n. sp.; cited by Gabunia, pers. com., 1981 (*nomen nudum*)

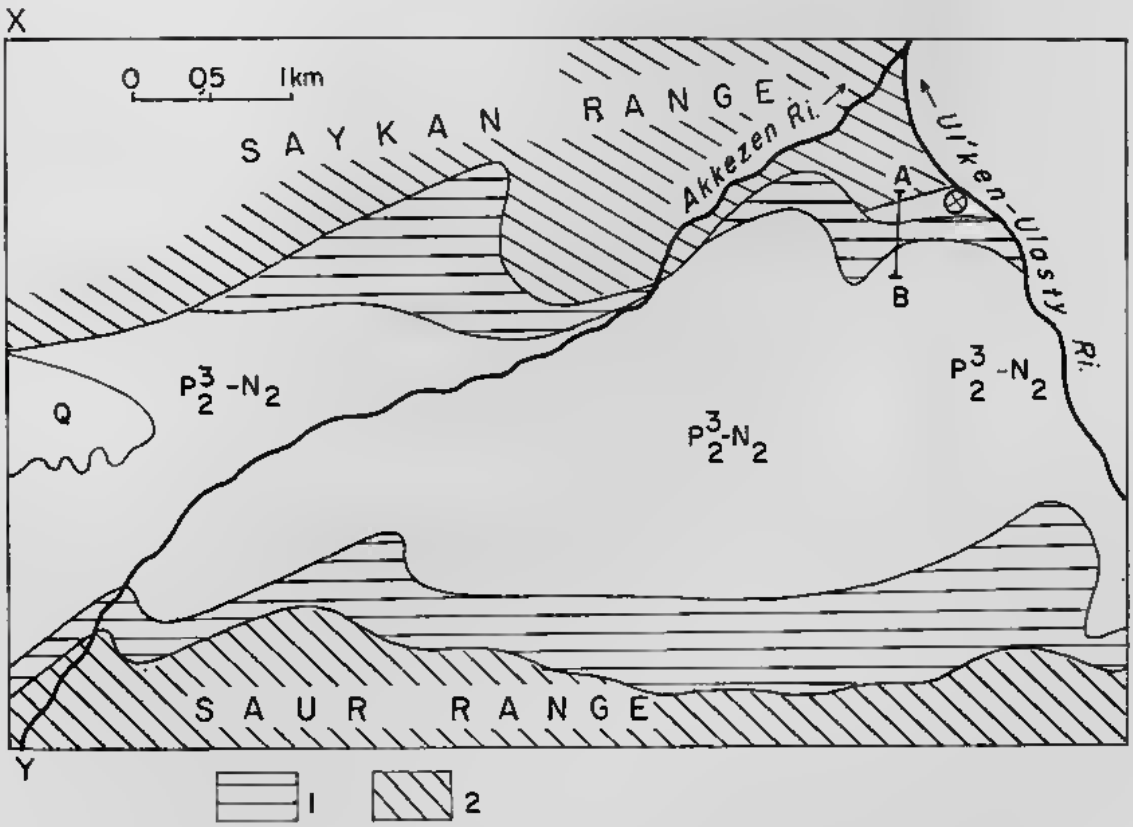

FIG. 95. — Sketch map of Areal Site III on the Ul'ken-Ulasty River, Kazakh S.S.R. The fossil locality indicated is Prirechnoye in the Obayla Svita. **1**. the Sargamys Svita; **2**. Paleozoic rocks. X and Y join X' and Y' on Fig. 98, forming a continuous map. Modified from Borisov, 1984.

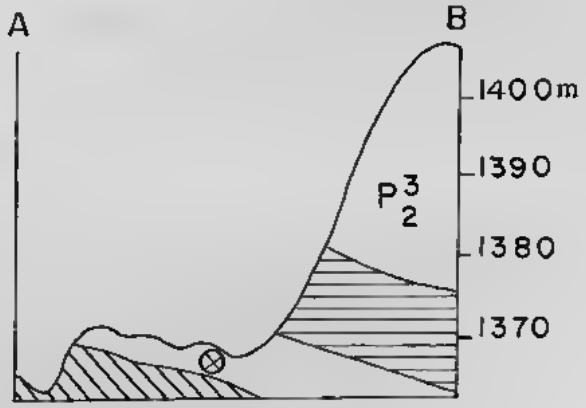

FIG. 96. — Diagrammatic cross section of Areal Site III on the Ul'ken-Ulasty River, Kazakh S.S.R. Same legend as for Fig. 95. Modified from Borisov, 1984.

Source : MNHN, Paris

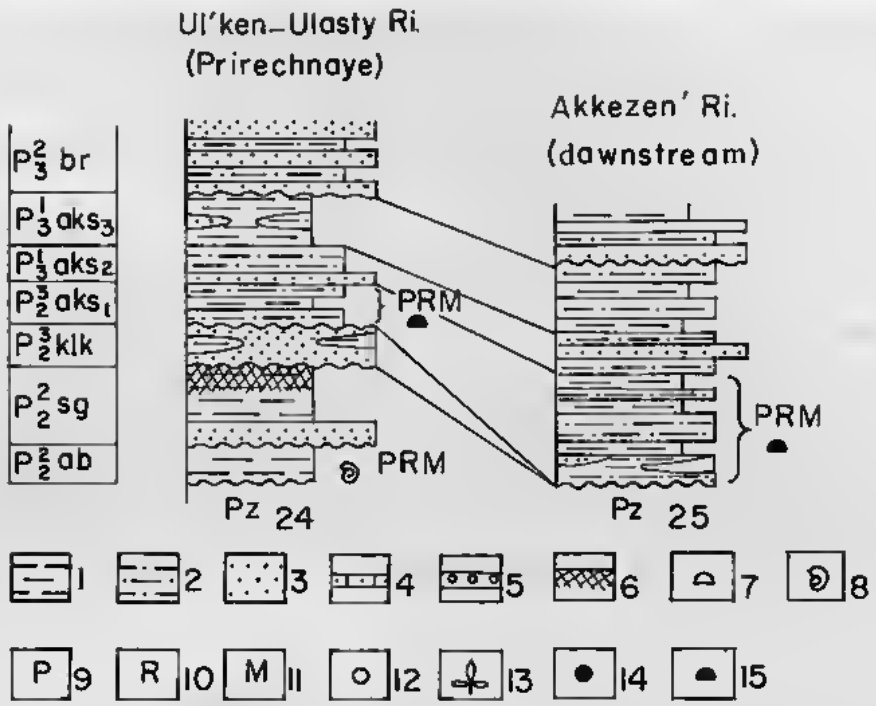

FIG. 97. — Stratigraphic sections in the Kenderlyk Basin, southeast of the Zaysan Depression, Kazakh S.S.R., on the Akkezen' and Ul'ken-Ulasty Rivers. **1.** clay; **2.** silt; **3.** sand; **4.** sandstone; **5.** pebble conglomerate; **6.** erosional crust; **7.** ostracods; **8.** mollusks; **9.** fish (Pisces); **10.** reptiles; **11.** mammals; **12.** charophytes; **13.** imprints of plants; **14.** spores and pollen; **15.** abundant coprolites. nr. — Nura; osh — Oshaganda; br — Buran; ks — Kusto; aks$_3$ — upper part of the Aksyir Svita; aks$_2$ — middle part of the Aksyir Svita; aks$_1$ — lower part of the Aksyir Svita; klk — Kyzylkain; chb — Chaybulak; knk — Konurkura; sg — Sargamys; ob — Obayla; chk — Chakpaktas; kk — Kiinkerish; ds — Dyusyumbay; akt — Aktobe; K_2 — late Cretaceous; PZ — Paleozoic. Modified from a drawing provided by B. A. Borisov.

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Zaysan Depression

Upper Obayla Subsvita **middle Eocene**

Locality: Areal site V, Aksyir River (Chernyy Trioniks)

The mammals from the upper part of the Obayla Svita were discovered in the 1960's by Chkhikvadze and Shevyreva on the right bank of the Aksyir River, notably in the area of the axis of the first Aksyir anticline. The assemblage, which included dark colored turtle carapace remains (which explains the locality name), occurs 3 m from the top of the svita; the latter is 20-25 m thick. Contact with the underlying Chakpaktas Svita is not visible; the overlying Sargamys Svita is discordant and covers the Obayla by different horizons.

Soviet workers have also considered this part of the Obayla Svita as referable to the middle Eocene, but the mammalian evidence is not conclusive.

Source : MNHN, Paris

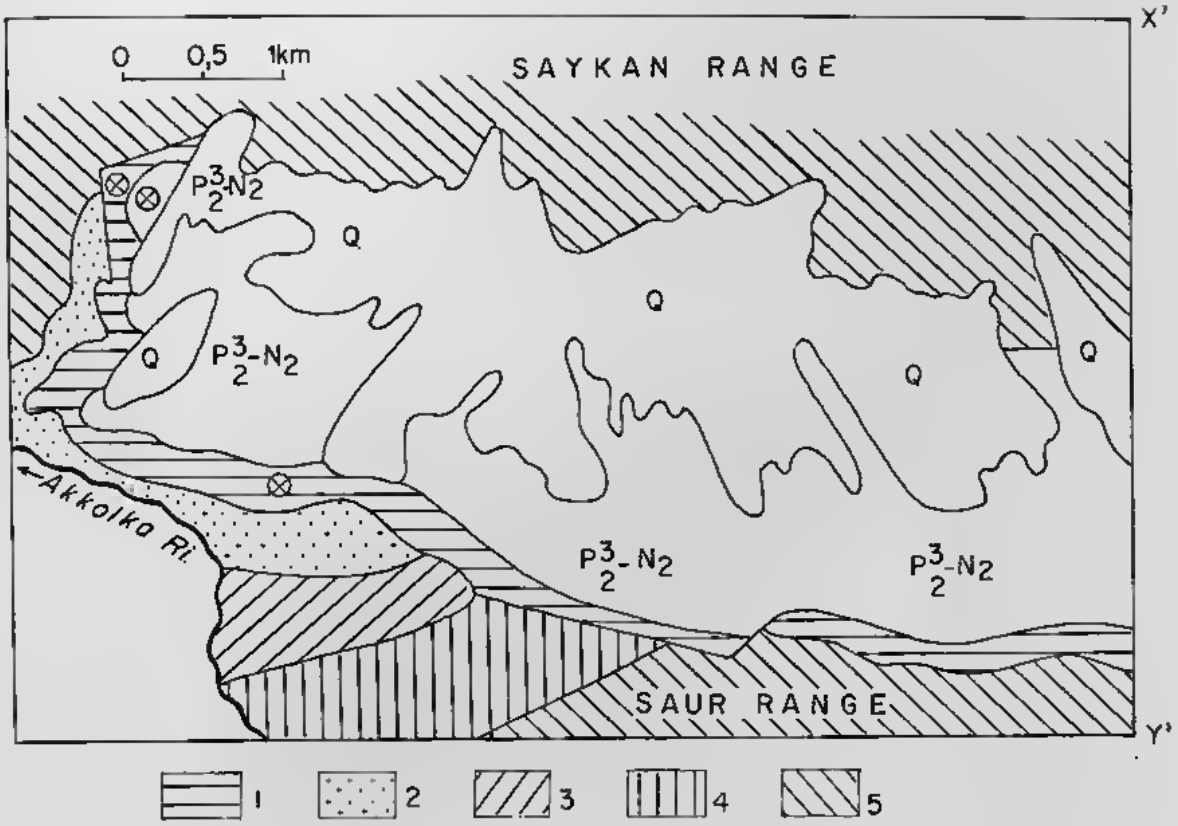


FIG. 98. — Sketch map of Areal Site IX on the Akkolka River, Kazakh S.S.R. Three fossil mammal localities are situated upstream on the Akkolka River. Two of them are of minor importance and are located in the northwest part of the map; the more western of the two is in the Sargamys Svita and the other in the lower part of the Aksyir Svita. The principal locality, called Akkolka, is the more southern one in the Sargamys. 1. Sargamys Svita; 2. Late Cretaceous; 3. Jurassic; 4. Triassic; 5. Paleozoic; X' and Y' join X and Y on Fig. 95, forming a continuous map. Modified from Borisov, 1984

Fauna of the upper Obayla Subsvita

(furnished by Dr. Shevyreva and Prof. Gabunia)

RODENTIA

CTENODACTYLIDAE Indet.; cited by Shevyreva, pers. com., 1981 (as Chapattimyidae indet.)

PERISSODACTYLA

DEPERETELLIDAE Indet.; cited by Gabunia, pers. com., 1981

HYRACODONTIDAE
— *Triplopus chkhikvadzei* Gabunia, 1984
— *Forstercooperia* sp.; cited by Gabunia, 1984

ARTIODACTYLA

FAMILY Indet.
— *Paraphenacodus solivagus* Gabunia, 1971
— *Paraphenacodus* cf. *solivagus* Gabunia, 1971; cited by Gabunia, 1982

Source : MNHN, Paris

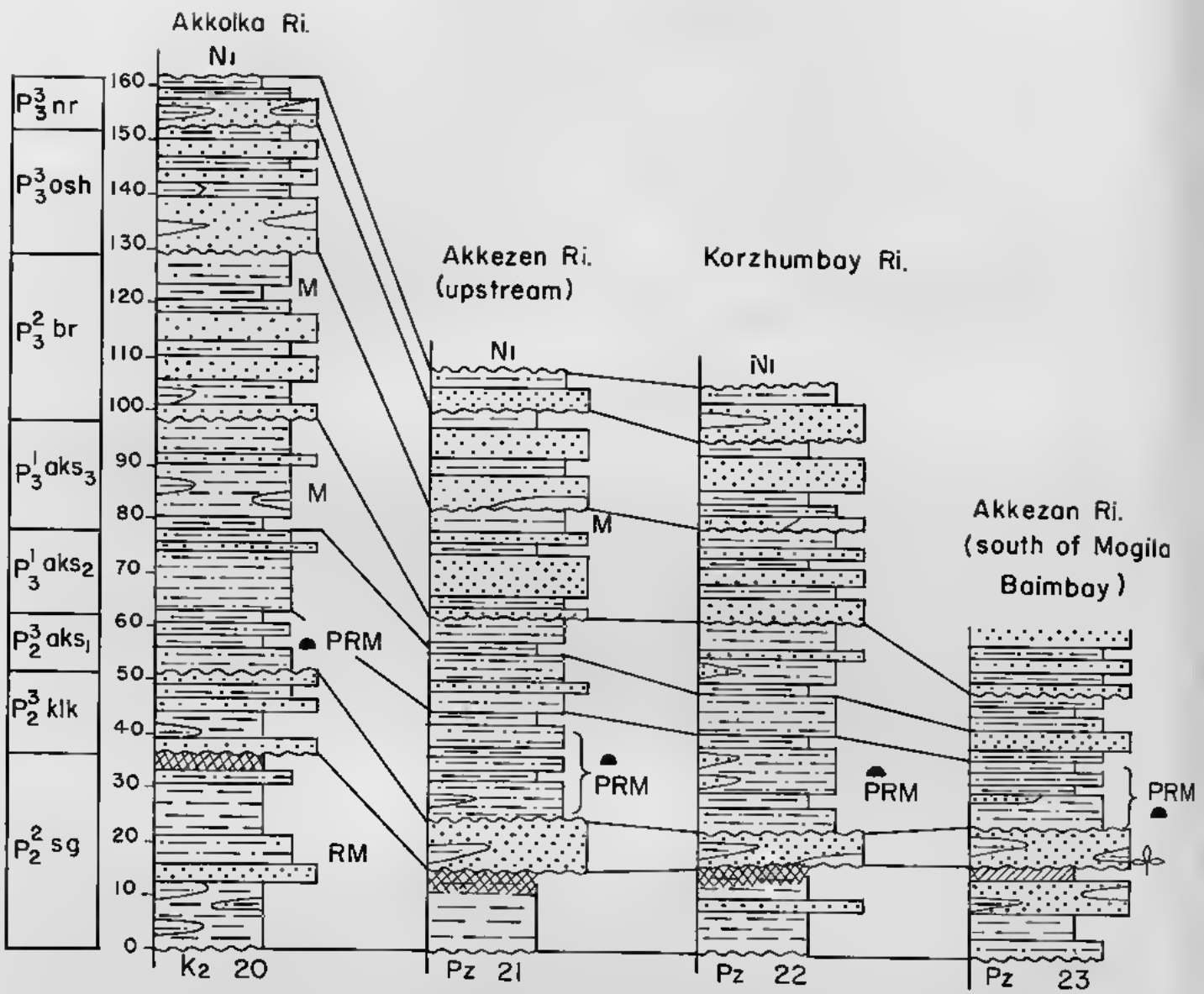


FIG. 99. — Stratigraphic sections in the Kenderlyk Basin, southeast of the Zaysan Depression, Kazakh S.S.R., on the Akkolka and Akkezen' Rivers. For legend, see Fig. 97. Modified from a drawing provided by B. A Borisov.

Source : MNHN, Paris

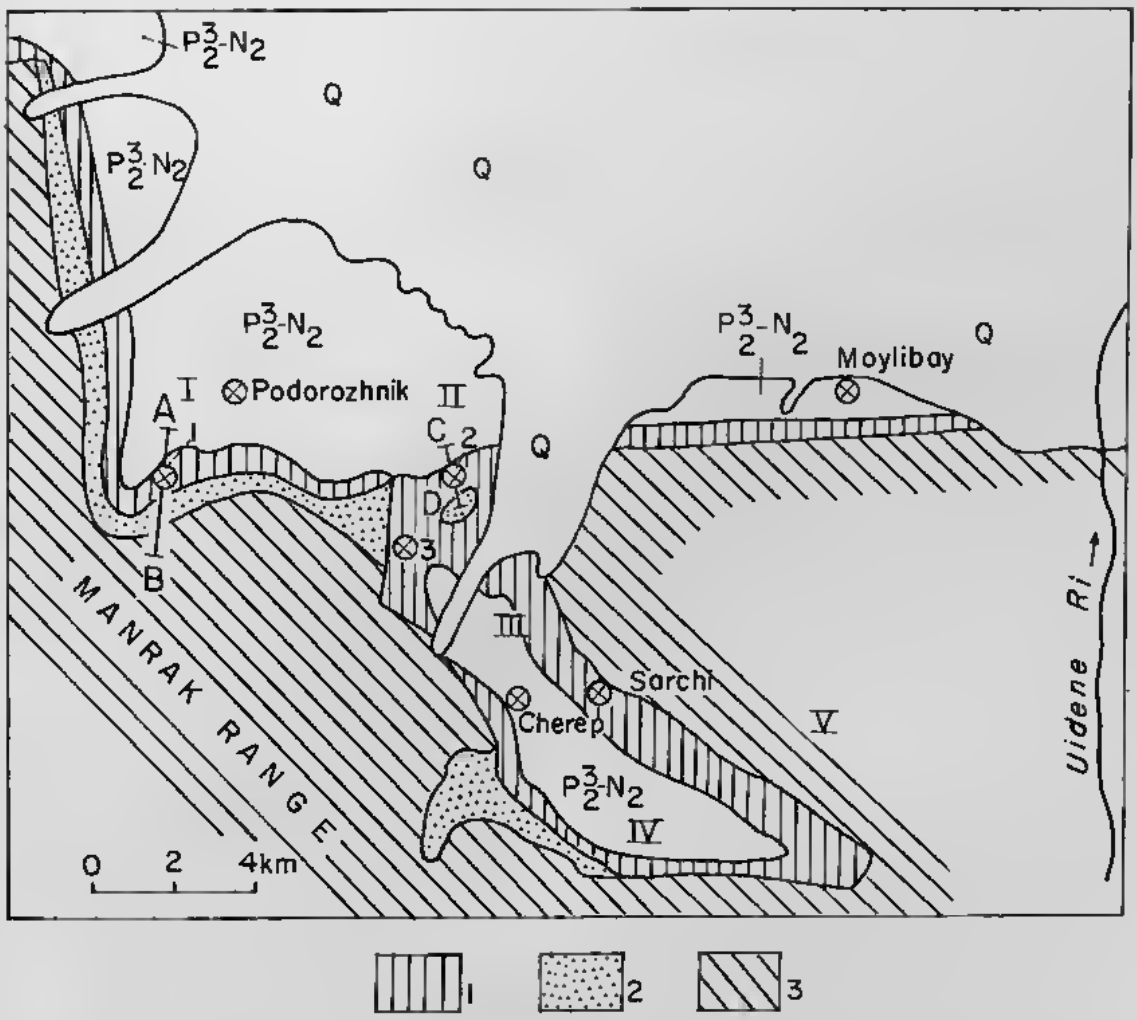


FIG. 100. — Sketch map of the fossiliferous region northeast of the Manrak Range, Zaysan Basin, Kazakh S.S.R. Placement of the rivers traversing the area (in a generally south to north direction) was only possible by the indication of points along their course. I. Konurkura River, a left tributary of the Dzhamangora River; II. Chaybulak River; III. Bulkair Valley; IV. Karasu River; V. Maylibay River. Fossil locality 1, Sopka Otpetchotok, is situated east of the Konurkura River, to the east of the section line A-B, in the Konurkura Svita. Locality 2 represents the sites Belaya Banka and Chernaya Banka in the valley of the Chaybulak River. Locality 3 is Osobaya Sopka in the valley of a left tributary of the Chaybulak River. Podorozhnik is on a right tributary of the Dzhamangora River; Maylibay locality is on the right bank of the Maylibay River; Sarchi is on the left bank of the Karasu River; and Cherep is in the Bulkair Valley. Osobaya Sopka, Belaya and Chernaya Bankas are in Areal Site IV; Areal Site VIII is represented by Sopka Otpetchotok and Cherep. 1. the combined Obayla, Sargamys and Konurkura Svitas, 2. late Cretaceous; 3. Paleozoic. Modified from Borisov 1984.

Source : MNHN, Paris

U.S.S.R.
KAZAKHSTAN S.S.R.
VOSTOCHNO KAZAKHSTANSKAYA OBLAST'
ZAYSAN DEPRESSION

Sargamys Svita **middle Eocene**

Localities: Areal Site V, Aksyir River (Vyshe Fermy = Verkniy), Bulat, Koluchka, Zhumyrtka; Karasu River (Sarchi); Areal Site IX, Akkolka River

The first mammalian remains from the Sargamys[116] Svita were discovered on the Aksyir River in 1966 by Borisov and Zhegallo. Later, Chkhikvadze and Shevyreva gave the name Koluchka to this site; furthermore, during the 1960's and 70's, they found all the other localities known in this svita.

Once again, the richly fossiliferous section on the left bank of the Aksyir River is responsible for most of the fossil mammals found. In the Sargamys Svita, which comprises the northern flank of the first Aksyir anticline, the Koluchka[117] locality is in the sands near the base; Bulat[118] is in overlying clays. The thickness of the svita is about 35 m and it dips steeply toward the north. It overlies the Obayla Svita unconformably and is covered by the Kyzylkain.

The Zhumyrtka[119] locality, on the southern flank of the first Aksyir anticline, was found 9 m from the base of the svita. The Sargamys Svita is here also situated between the Obayla and Kyzylkain Svitas. It can be noted, however, that the sands and clays of the Koluchka and Zhumyrtka localities on the north flank are missing in this section. The fossiliferous strata dip slightly southward.

The name Treugol'nik[120] was given to a floral locality situated in the Sargamys Svita on the Kalmakpay River. Below the flora, in the lower part of the svita, Chkhikvadze in 1980 discovered fossil vertebrates and perhaps mammals.

Upstream on the Aksyir River (and in contact with the Paleozoic), the Chakpaktas, Obayla, Sargamys and Kyzylkain Svitas are vertical. Mammals were discovered here in the Sargamys Svita (at Vyshe Fermy[121]), on the right bank of the river, 3 m from the base.

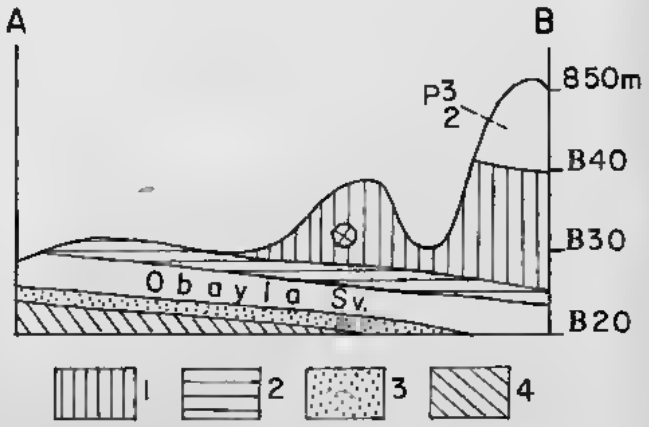


FIG. 101. — Diagrammatic cross section along the Konurkura River, showing the Sopka Olpetcholok locality in the Konurkura Svita, Kazakh S.S.R. 1. Konurkura Svita; 2. Sargamys Svita; 3. late Cretaceous sediments; 4. Paleozoic rocks. Modified from Borisov, 1984

On the left bank of the Karasu[122] River, mammals were collected at the foot of the 2.5 high Sarchi hillock. The horizontal greenish brown clays which comprise the lower part of the Sargamys Svita cover the Paleozoic with a thickness of 3-4 m. In nearby outcrops it is unconformably overlain by the Konurkura Svita.

Here again, Soviet researchers have opted for

116 Sargamys = yellow or wilted.
117 Koluchka = spine.
118 Bulat = steel(?)
119 Zhumyrtka = egg.
120 Treugol'nik = triangle.
121 Vyshe Fermy: above the farm; verkniy = upper.
122 Karasu = black water.

Source : MNHN, Paris

a middle Eocene age. This is supported by an important collection of plants (found on the right bank of the Kalmakpay River) that suggests a time interval situated between the Paleocene and the late Eocene. The mammalian element of the svita is inadequate but suggests a middle Eocene age.

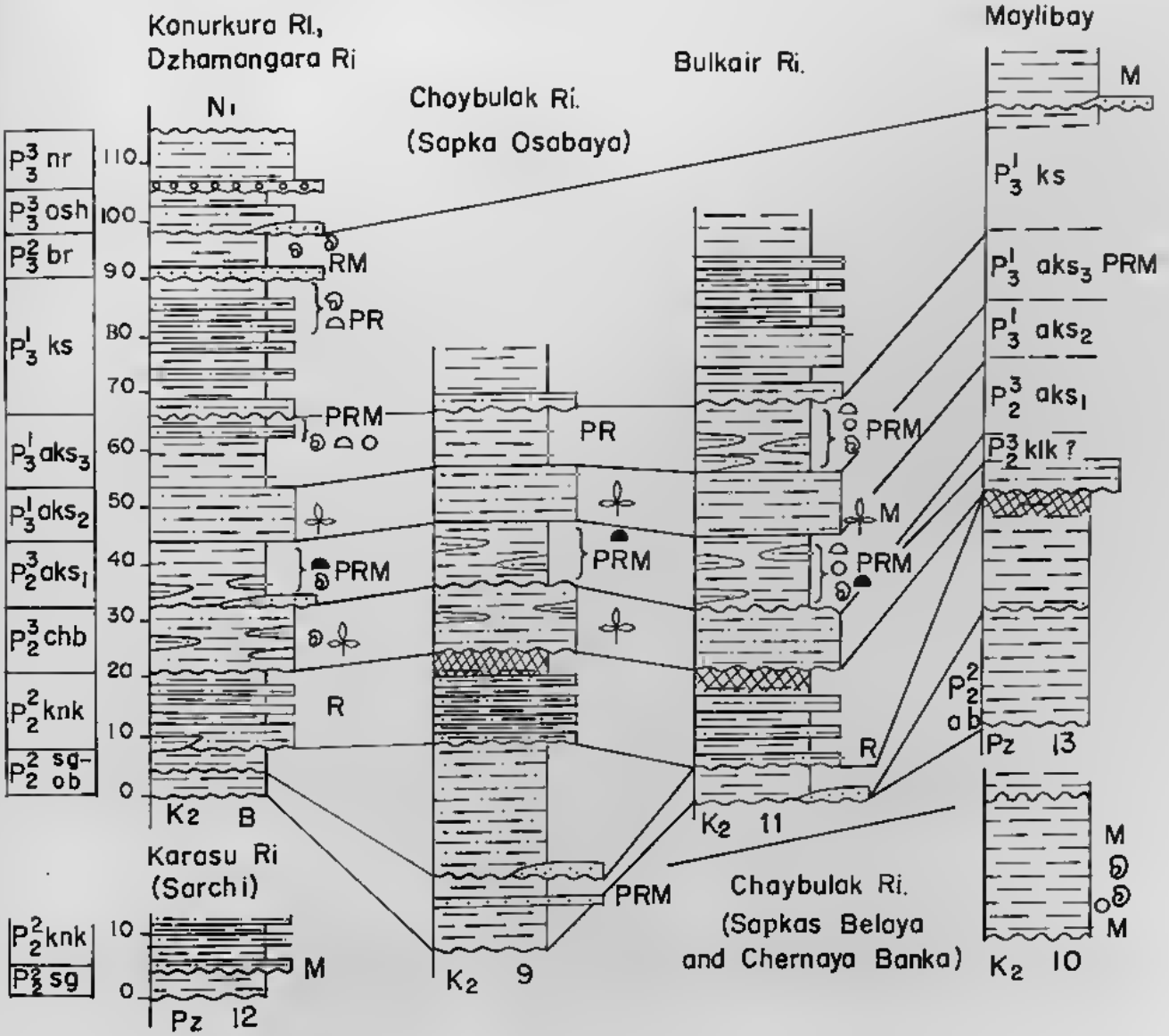


FIG. 102. — Stratigraphic sections in the south-central part of the Zaysan Depression, Kazakh S.S.R., on the Konurkura, Chaybulak, Bulkair and Maylibay Rivers. For legend, see Fig. 97. Modified from a drawing provided by B. A. Borisov.

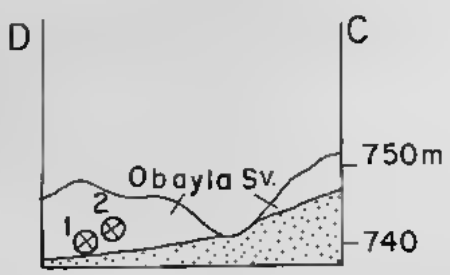


FIG. 103. — Diagrammatic cross section along the Chaybulak River, Kazakh S.S.R., showing the localities in the Obayla Svita. 1. Chernaya Banka; 2. Belaya Banka. Same legend as in Fig. 101. Modified from Borisov 1984.

Source : MNHN, Paris

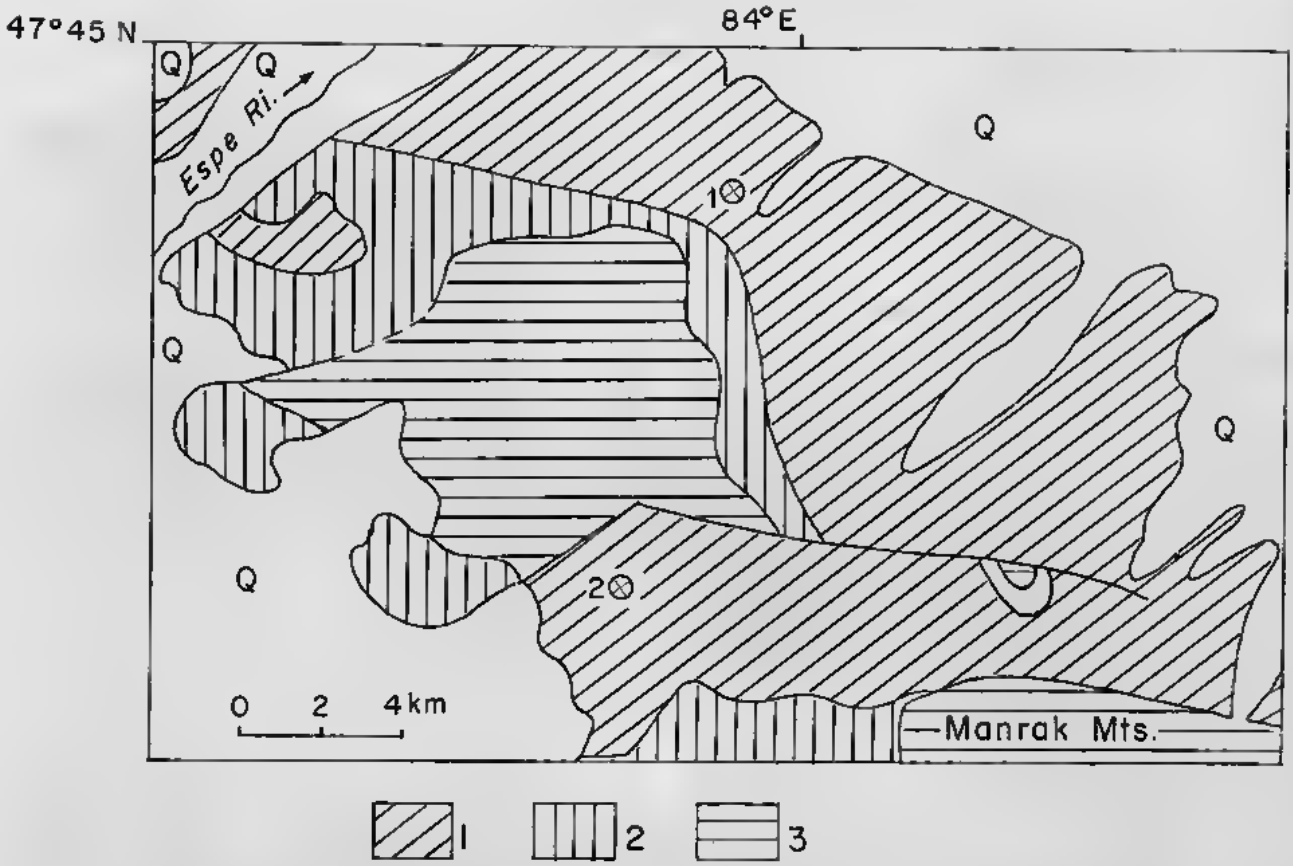


FIG. 104. - Sketch map of the western limit for fossil vertebrates in the Zaysan Depression, Kazakh S.S.R. Locality 1 is Sopka Talagay, in the Buran Svita, and locality 2 is Dzhal'ma, a site in the upper part of the Aksyir Svita. Both are situated along the Tayzhuzgen River. **1.** Tertiary; **2.** Mesozoic; **3.** Paleozoic. Modified from Borisov, 1984.

Source : MNHN, Paris

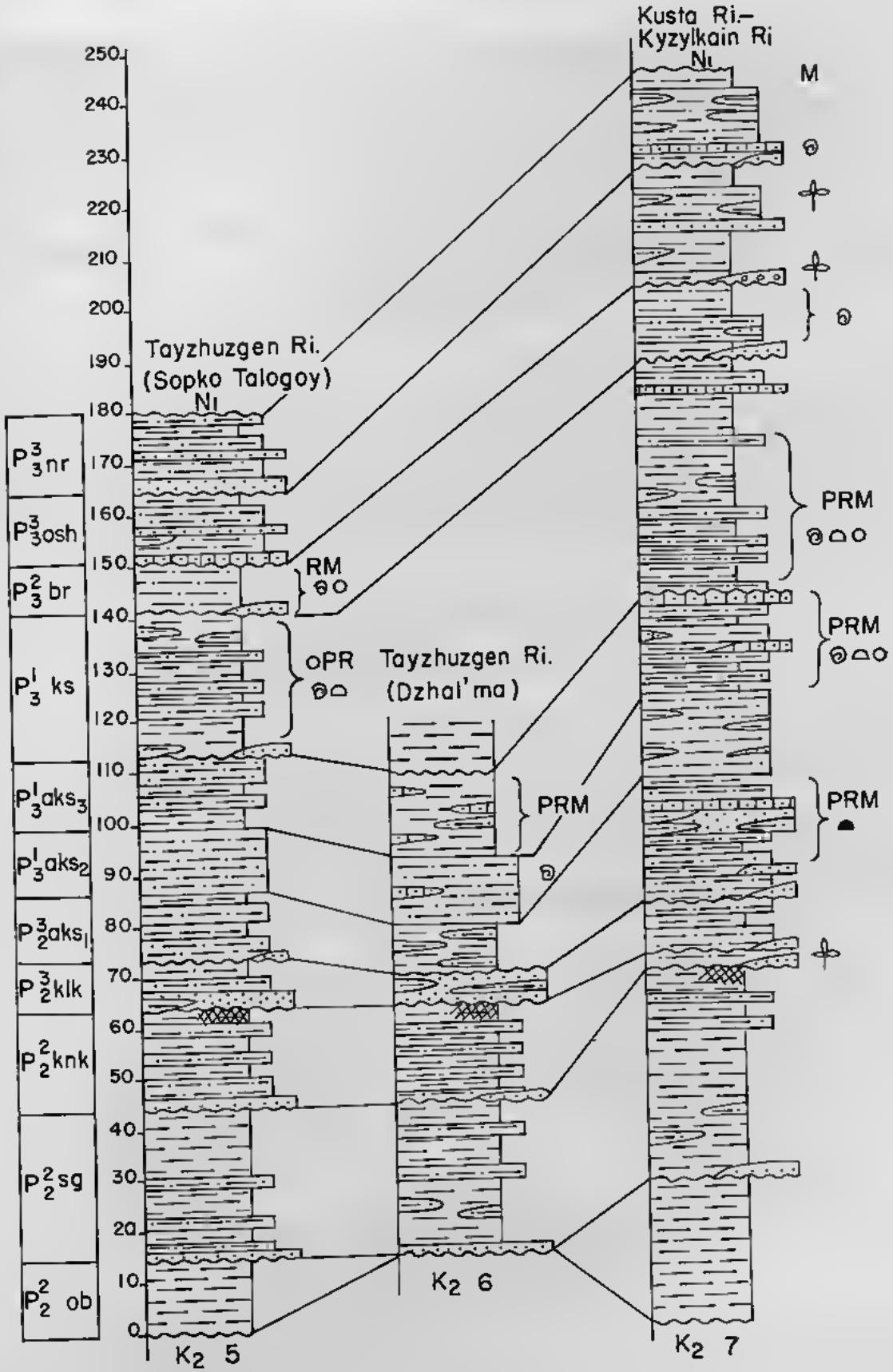


FIG. 105. — Stratigraphic sections in the southwestern part of the Zaysan Depression, Kazakh S.S.R., on the Tayzhuzgen River and between the Kusto and Kyzylkain Rivers. For legend, see Fig. 97. Modified from a drawing provided by B. A. Borisov.

Source : MNHN, Paris

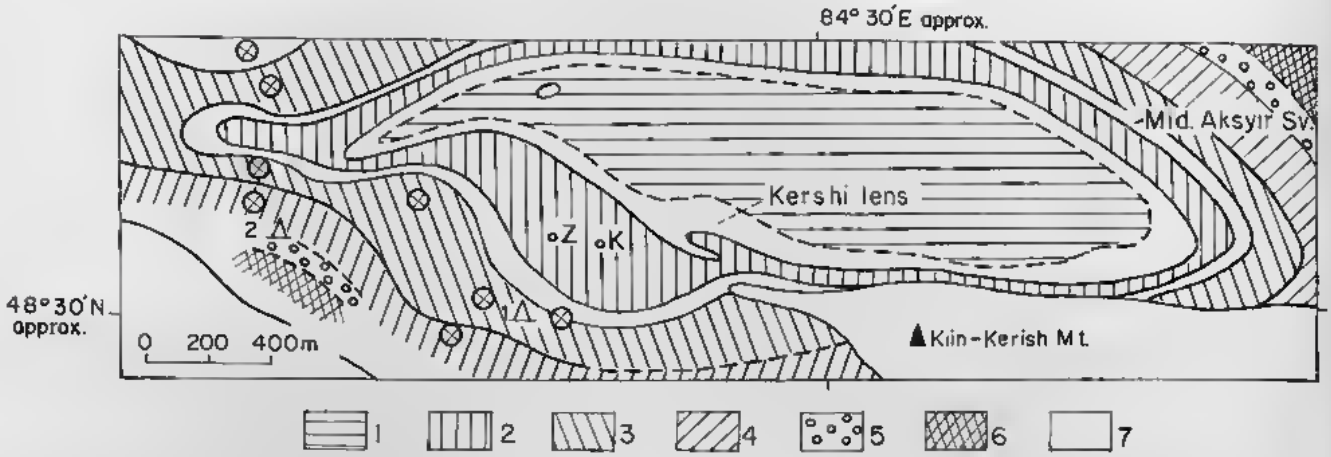


FIG. 106. — Geologic sketch map showing the fossil vertebrate localities near Kiin-Kerish Hill, Zaysan Depression, Kazakh S.S.R. 1. Paleocene; 2. lower part of the Aksyir Svita; 3. upper part of the Aksyir Svita; 4. Kusto Svita; 5. Buran Svita?; 6. Oshaganda Svita?; 7. Pleistocene. Z is the site where the type specimen of *Zaisanamynodon* was found; K is the discovery site of *Kiinkerishella*. Camp sites are indicated by a pyramidal structure. N° 1 is the Biryukov Camp near Sopka A; N° 2 is called Camp Yakor' (= anchor; because of the shape of a nearby sopka) and is the campsite of the present Shevyreva-Chkhikvadze expeditions. Modified from a sketch provided by B. A. Borisov.

Fauna of the Sargamys Svita

(furnished by Dr. Shevyreva, Prof. Gabunia and Dr. Gureyev)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

RODENTIA

CTENODACTYLIDAE Indet.; cited by Shevyreva, pers. com., 1981 (as Chapattimyidae indet.)

MIXODONTIA

FAMILY Indet.; cited by Gabunia, pers. com., 1984

CONDYLARTHRA

MESONYCHIDAE Indet.; cited by Gabunia, 1982; described by Gabunia, 1984

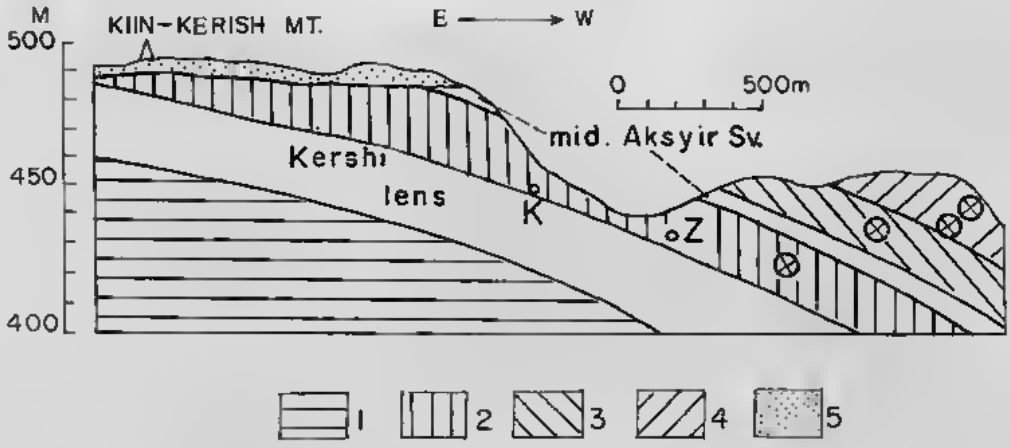


FIG. 107. — Diagrammatic cross section parallel to the axis of the anticline of Kiin-Kerish Mountain, Areal Site VI, on the northern side of Lake Zaysan, Kazakh S.S.R. 1. Paleocene; 2. lower part of the Aksyir Svita; 3. upper part of the Aksyir Svita; 4. Kusto Svita; 5. Quaternary. Modified from Il'inskaya, 1960.

Source : MNHN, Paris

PERISSODACTYLA

HELALETIDAE Indet.; cited by Gabunia, 1982

LOPHIALETIDAE Indet.; cited by Gabunia, 1977

HYRACODONTIDAE
- — *Triplopus chkhikvadzei* Gabunia, 1984 (= *Triplopus sargomyssensis* n. sp.; cited by Gabunia, 1982, *nomen nudum*)
- — *Forstercooperia* sp.; cited by Gabunia, pers. com., 1980 (= *Forstercooperia crudus* Gabunia, 1977, *nomen nudum*)
- — Hyracodontidae indet.; cited by Gabunia, 1977
- — *Prohyracodon* sp.; cited by Gabunia, 1982

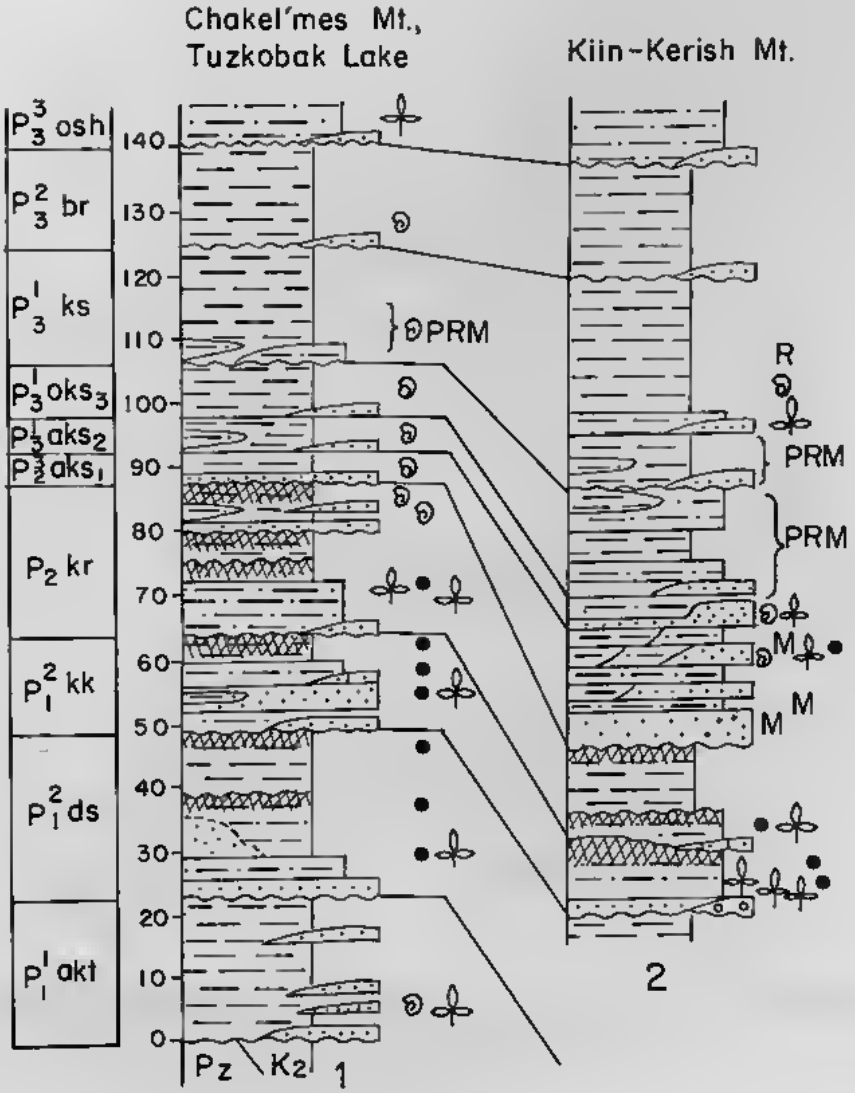


FIG. 108. - Stratigraphic sections in the northwestern part of the Zaysan Depression, Kazakh S.S.R., at Chakel'mes and Kiin-Kerish Mountains. For legend, see Fig. 97. Modified from a drawing provided by B. A. Borisov.

Source : MNHN, Paris

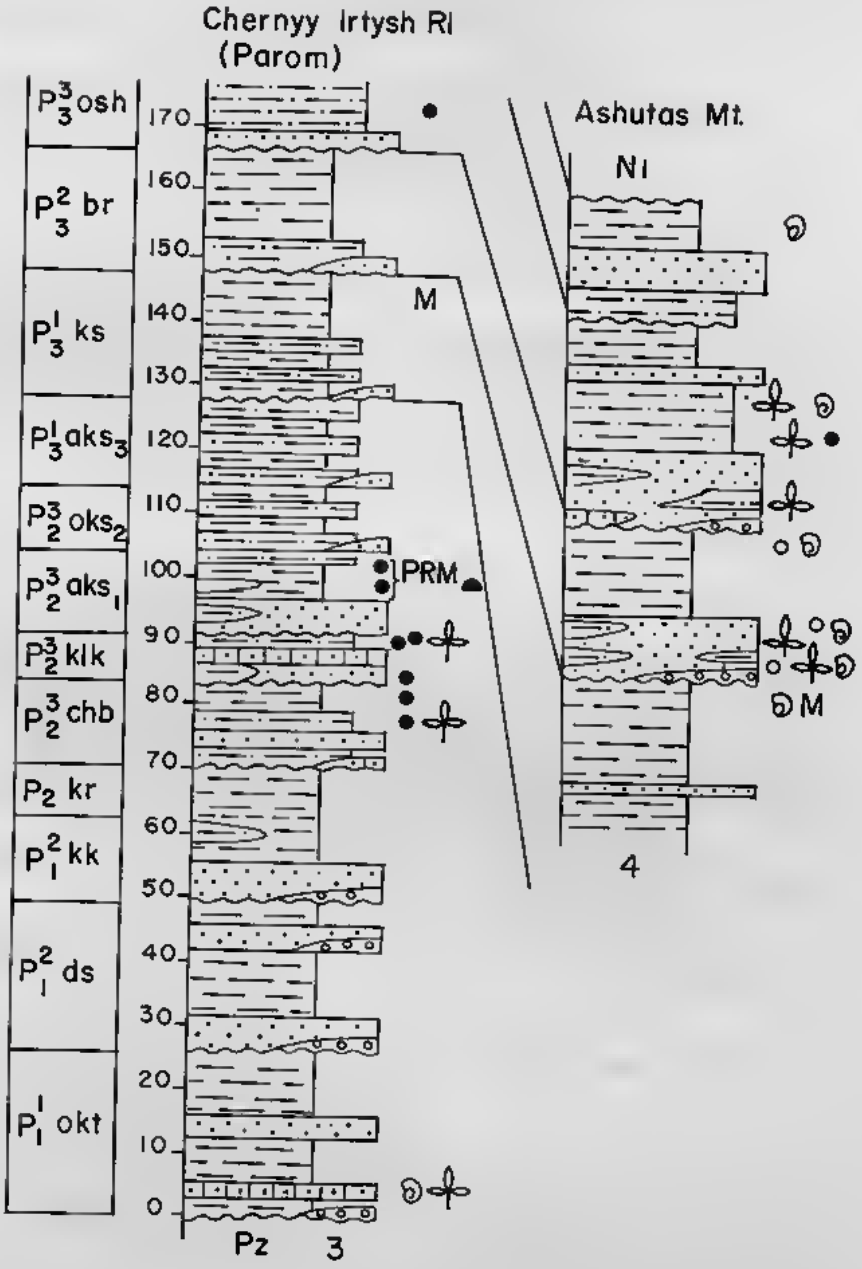


FIG. 109. — Stratigraphic sections in the northeastern part of the Zaysan Depression, Kazakh S.S.R., on the Chernyy Irtysh River and at Ashutas Mountain. For legend, see Fig. 97. Modified from a drawing provided by B. A Borisov.

Source : MNHN, Paris

Lat. 39°46′ N, approx.
Long. 69°27′ E, approx.

Fig. 3, n° 12

U.S.S.R.
KIRGIZ S.S.R.
Leninabad Oblast'
Fergana Depression

Alay Svita **middle Eocene**

Locality: Andarak 1

The village of Andarak is in the southwest part of the Fergana Depression, 6 km southwest of Isfana city. The locality itself is situated several hundred meters east of the village. The first vertebrate from here to be known to the scientific community was a bird, *Eobalearica*, whose remains were described by Gureyev in 1949. This was supplemented by a single tooth of a mammal referred to *Deperetella* by Belyayeva in 1962. In the summer of 1964 a team from the Paleontological Institute of the Academy of Sciences of the U.S.S.R. visited the site and collected additional material, particularly from the upper fossiliferous horizon in which the *Deperetella* specimen was found. A reconnaissance trip was made in 1967 and in 1975 more excavations were undertaken. A detailed lithologic section was made south of the village, on the right bank of the Andarak stream (see Gekker *et al.*, 1962); the essentials are given below:

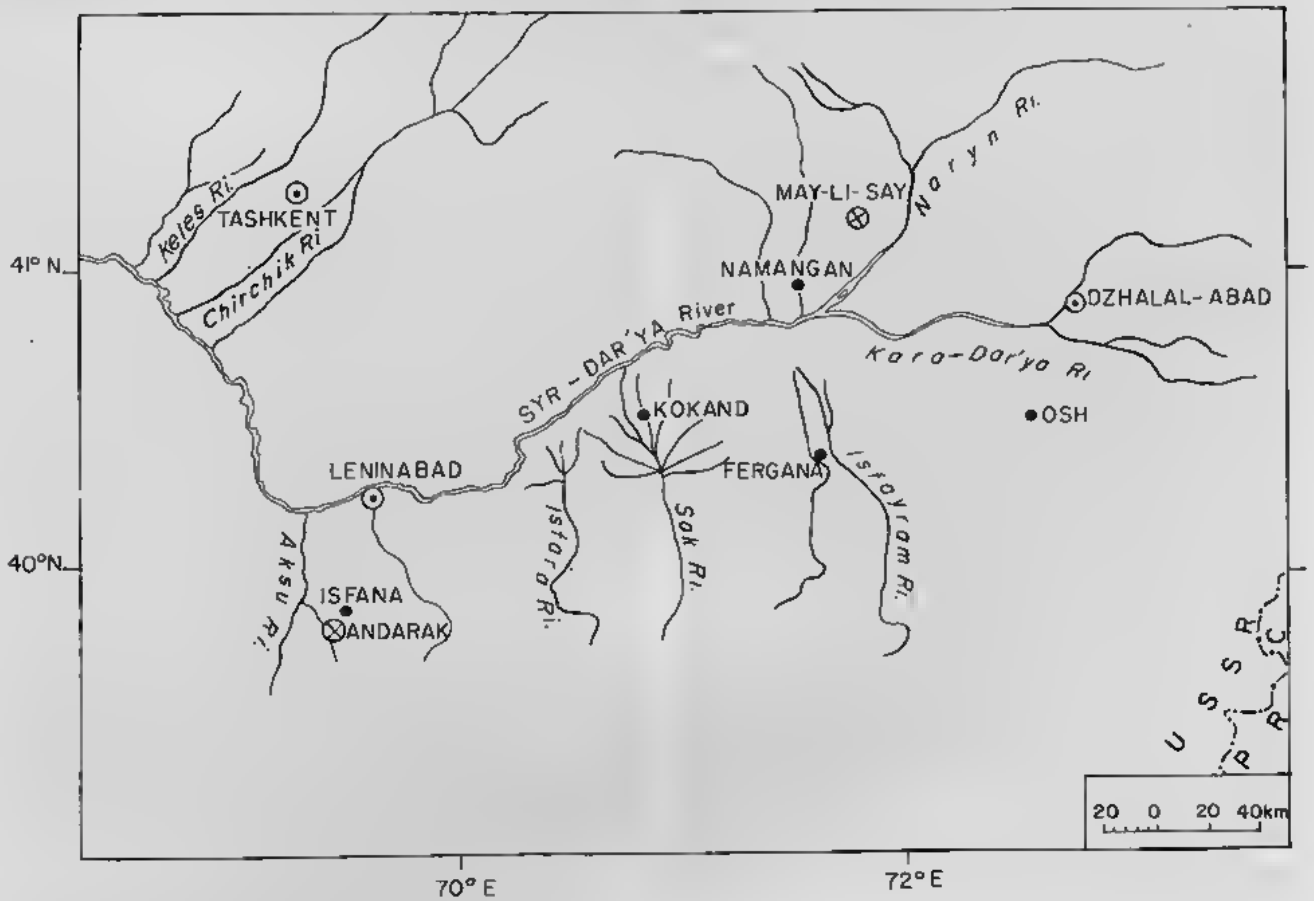


FIG. 110. — Fergana Depression, showing the position of the localities Andarak 1 and II (Kirgiz S.S.R.) and Mayli-Say (Uzbek S.S.R.). Modified from Gekker *et al.*, 1962.

Source : MNHN, Paris

layer 3	fine-grained detrotal limestone sandy limestone		
(level of mammal bones)	conglomerate	observed thickness.....	2.5 m
	unconformity		
layer 2	white calcareous silt with burrows and cobble lenses	.....	5 m
layer 1 (level of fossil bird bone)	conglomerate basically consisting of pebbles of Paleozoic limestone	.....	1.3 m
	thin bed of white, porcelain-like limestone	.....	0.4 m
	unconformity		
	Paleozoic limestone		

Layers 1 to 3 are regarded as a single unit in littoral marine deposits. Much of the collection of 1964 came from a conglomerate of irregular distribution that lies at the base of the top bed; it also yielded oysters and the internal molds of pelecypods and gastropods, as well as the teeth of sharks and rays. The principal part of the collecting was done on the talus and in the cliff along the right bank of the stream, but the beds are also exposed on the left bank where the amynodont materiel was found by Zhegallo. Further material was found here in 1975 by the crew led by Reshetov.

Klebanova (1966) was the opinion that, based on the fauna, the upper fossiliferous deposit was of late Alayian Age (see usage in Gekker *et al.*, 1962), while the lower deposit and the intervening silts would be middle and probably partially early Alayian. In Gekker *et al.* (1962) the layers 1 and 2 are referred to the Suzak Svita, which is placed in the early Eocene, and layer 3 is considered early Alayian, a svita representing the middle Eocene. In 1978, Reshetov *et al.* were definite in referring the vertebrate levels of Andarak I and Andarak II to the Alay Stage (but the lower fossil level of Andarak I was not cited specifically) and noted that the large marine fauna of the latter correlated with the Lutetian and Bruxellian Stages of Western Europe. Dmitriyeva & Nesmeyanov (1982) rediscussed the stratigraphy and concluded that the bone-bearing Alay Svita was underlain by the Suzak Svita and overlain by the Massaget Svita.

In analyzing the single tooth (P2/) of *Deperetella ferganica*, Radinsky (1965) was of the opinion that it seemed morphologically closer to *Teleolophus*, and was even possibly synonymous with *T. magnus*. Reshetov (1975) disagreed and retained the species provisionally in *Deperetella* pending more complete material (but nothing more is as yet known), suggesting that it may be a primitive representative of the genus.

With respect to the Andarak amynodont, its comparison was also impeded by the incompleteness of the specimen, but Belyayeva (1971) has remarked that the species is one of the smallest of the early amynodonts and that it appears to be somewhat primitive; it is specialized, however, in the shortening and widening of the anterior premolars.

Correlation of the Andarak I mammalian faunule cannot be very precise if one considers it alone. Additional support for a middle Eocene age, however, is obtained from the marine fauna. Also, considerably more mammalian material was collected from the contemporary Andarak II locality, to which the reader is referred.

Source : MNHN, Paris

Fauna of Andarak I

RODENTIA Indet., pers. com., Shevyreva, 1981

PERISSODACTYLA

CHALICOTHERIIDAE Indet.; cited by Reshetov, pers. com., 1984

DEPERETELLIDAE — *Deperetella ferganica* Belyayeva, 1962
(= *Teleolophus? ferganica* (Belyayeva, 1962) Radinsky, 1965)
(= *Deperetella ferganica* Belyayeva, 1962, *in* Reshetov, 1975)

LOPHIALETIDAE? — *Rhodopagus minutissimus* Reshetov, 1979
(= *Rhodopagus minutissimus* Reshetov *et al.*, 1978 (*nomen nudum*))

AMYNODONTIDAE — *Lushiamynodon? kirghisiensis* Belyayeva, 1971 (generic designation considered unquestioned by Reshetov, pers. com., 1984)

Lat. 39°46′ N
Long. 69°27′ E

Fig. 3, n° 12

U.S.S.R.
KIRGIZ S.S.R.
Leninabad Oblast'
Fergana Depression

Alay Svita **middle Eocene**

Locality: Andarak II

Andarak II was discovered during field work by a crew led by Rozhdestvenskiy in 1969, but the material collected was lost. Another team returned in 1975 (led by Reshetov) and spent a month of intensive collecting. This new locality is about 1 km north of Andarak I (near the old road to Isfana) and is situated in a steep-sided gully that cuts across the strike of the Tertiary deposits from SW to NE. Most importantly, it offers better outcrops that those at Andarak I.

The characters of the lithology and of the included invertebrates allow it to be referred to the group of western sections discussed by Gekker *et al.* (1962) and correlated with that part of the section below the upper fossiliferous level cited in the discussion of Andarak I. The remains of organisms in the locality are varied, with both marine and terrestrial forms occurring together. Although about 50 tons of matrix were reportedly screenwashed, mammals are rare.

Reshetov *et al.* (1978) emphasize the close relationships of the marine fauna to those of Western Europe, citing, for example, the sharks and rays as being characteristic of the Lutetian deposits in the Paris Basin and of the Bruxellian sands in Belgium. The turtles are apparently unique; the *Hadrianus* material seems to be more evolved than similar turtles from the Obayla Svita of the Zaysan Depression. The rodent, *Petrokozlovia*, is closer to the species known from the Khaychin Svita (Mongolia) than to that from the Obayla Svita.

Even with the considerably enlarged mammalian assemblage now known from the Fergana Depression its correlation with other Asian faunas is not easy; few of its mammals are also known in other localities and the dating for the latter is sometimes contradictory; also, much of the material remains to be studied. Andarak offers one of Asia's best possibilities for marine dating, but it should be kept in mind that Andarak's marine fauna is that of an embayment, not of the open sea, and that many forms are endemic.

Source : MNHN, Paris

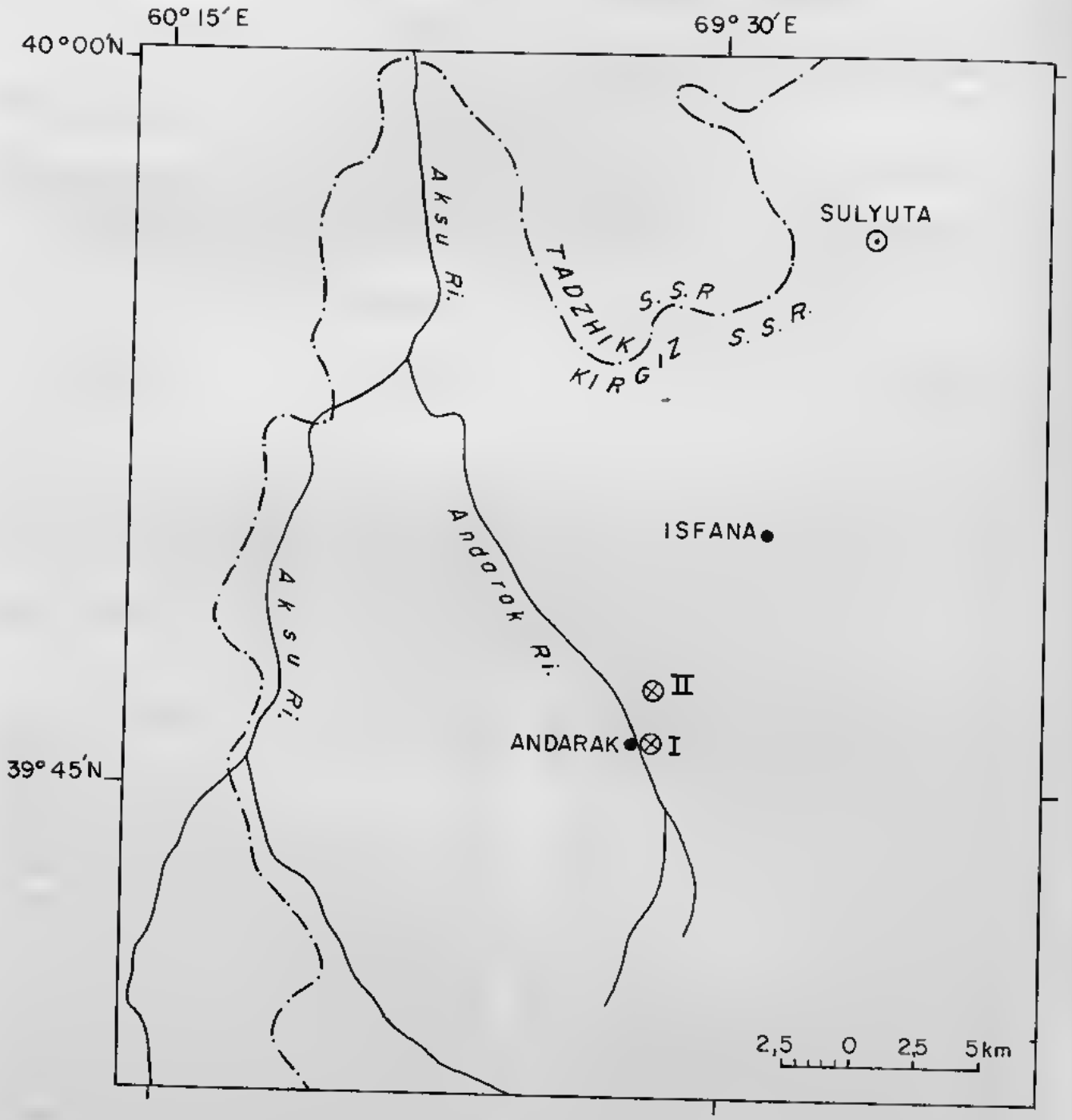


FIG. 111. — The relative positions of the localities Andarak I and Andarak II, Kirgiz S.S.R.. Modified from a map provided by G. V. Shkurkin.

Source : MNHN, Paris

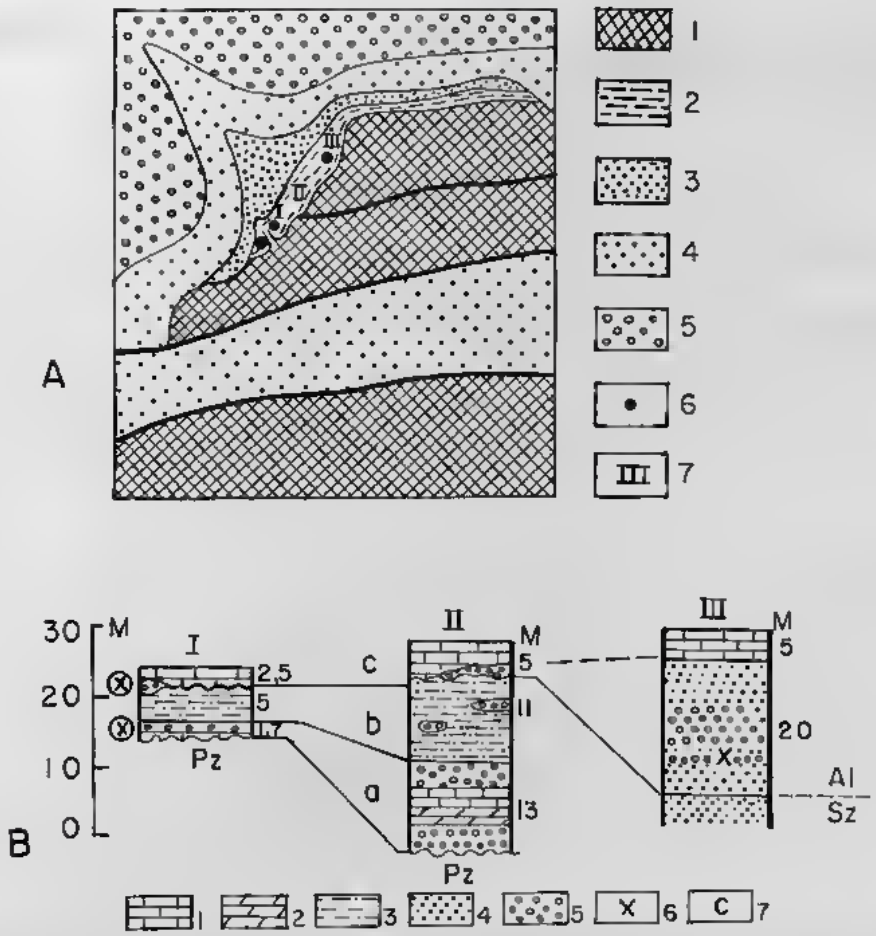


FIG. 112. —— A, Diagrammatic sketch of the region of Andarak, Kirgiz S.S.R., showing the situation of the fossil localities. **1.** Paleozoic rocks; **2.** Eocene molasse beds; **3.** Massaget Svita; **4.** Akzaray Svita; **5.** Koktyurlok Svita; **6.** fossil mammal locality; **7.** number of the section given in B.

B, Sequence of sediments in the Andarak region. **I.** Section taken south of Andarak village; **II.** section east of Andarak village; **III.** section 3 km to the NE of the village. **1.** limestone; **2.** marl; **3.** pelite; **4.** sandstone; **5.** conglomerate; **6.** level of fossil vertebrates; **7.** a and b, members of the Suzak Svita (Sz); c, Alay Svita (Al); The increase in thickness of the beds can be seen toward the east, as well as important changes in facies. The fossil bird material came from bed a; the mammals are from bed b. Modified from Dmitriyeva & Nesmeyanov, 1982.

Fauna of Andarak II

INSECTIVORA

Erinaceomorpha indet.; cited by Reshetov *et al.*, 1978

LAGOMORPHA Indet.; cited by Reshetov, 1979

RODENTIA

CTENODACTYLIDAE — *Petrokozlovia* cf. *notos* Shevyreva, 1972; cited by Reshetov, 1978

— *Tamquammys* sp.; cited by Reshetov *et al.*, 1978

"SCIURAVIDAE" Indet.; cited by Reshetov *et al.*, 1978

"PARAMYIDAE" Indet. (2 forms); cited by Reshetov *et al.*, 1978

FAMILY Indet.; cited by Reshetov *et al.*, 1978

CONDYLARTHRA Indet.; cited by Resehtov *et al.*, 1978 (Mesonychidae, fide Reshetov, pers. com., 1984)

Source : MNHN, Paris

PERISSODACTYLA

CHALICOTHERIIDAE Indet.; cited by Reshetov *et al.*, 1978

LOPHIALETIDAE? — *Rhodopagus minutissimus Reshetov*, 1979 (= *Rhodopagus minutissimus* Reshetov *et al.*, 1978, *nomen nudum*)

— *Pataecops microdon* Reshetov, 1979 (= *Pataecops microdon* Reshetov *et al.*, 1978, *nomen nudum*)

HYRACODONTIDAE — *Forstercooperia*? sp.; cited by Reshetov, 1978 (generic designation considered unquestioned by Reshetov, pers. com., 1984)

AMYNODONTIDAE — *Lushiamynodon*? sp.; cited by Reshetov *et al.*, 1978

ARTIODACTYLA

DICHOBUNIDAE Indet.; cited by Reshetov *et al.*, 1978

Lat. 42° 33′ N
Long. 76° 25′ E approx.

Fig. 3, n° 8

U.S.S.R.
KIRGIZ S.S.R.
Issyk-Kul'skaya Oblast'

Chonkurchak Svita **middle Eocene**

Locality: Toru-Aygyr

The Toru-Aygyr[123] locality was discovered in 1964 by the geologist Vokhmintsev Zhukov on the southern flank of the Kungey-Alatau[124] Mountain Range at the southern end of the Toru-Aygyr Depression (a part of the Issyk-Kul'[125] Depression) and is in the Chonkurchak[126] Svita.

Based on collections made soon after that of Zhukov, Tarasov (1968) proposed two new species of Perissodactyla, the specimens of which came from level n° 3 (see below). More collecting was done in 1968, 1971 and 1975 by teams from the Paleontological Institute of the Academy of Sciences of the USSR (Moscow); the collections of 1971 and 1975 were particularly large. In 1973 a party from the Institute of Zoology of the Academy of Sciences of the Kazakhstan S.S.R. also made collections. Additional sorts of Perissodactyla were discovered, as well as Dinocerata and Artiodactyla, but the material is not yet described.

The Kirgiz red bed complex of central Tian Shan, mostly comprised of the Oligocene Usun Svita, is distributed throughout a series of depressions. Underlying the Oligocene deposits several formations of Eocene age have been named, each one identified with an individual system of depressions: the Kokturpak Svita occurs in the Naryn Depression, the Sulutgrek Svita is known in the Kolmoynok and western Chuy Depressions, and the Chonkurchak Svita is typically developped in the Issyk-Kul' system. All of these Eocene beds have been grouped into a single unit, the Kokturpak Svita, but current opinion appears to prefer preservation of the local stratigraphic terms.

The Chonkurchak Svita lies on early Paleozoic granite; contact is usually made by a light gray limey rock up to 4 m thick, often described as a chemogenic limestone. It is overlain by the Dzhetyoguz Svita characterized by reddish silts with intercalations of sandstone and gravelites of

123 Toru-Aygyr (= Toruaĭgyr) = gray horse.
124 Kungey-Alatau = the slope of the varicolored mountain (ala-tau) exposed to the sun.
125 Issyk-Kul' = warm water lake.
126 Chonkurchak = big bell.

Source : MNHN, Paris

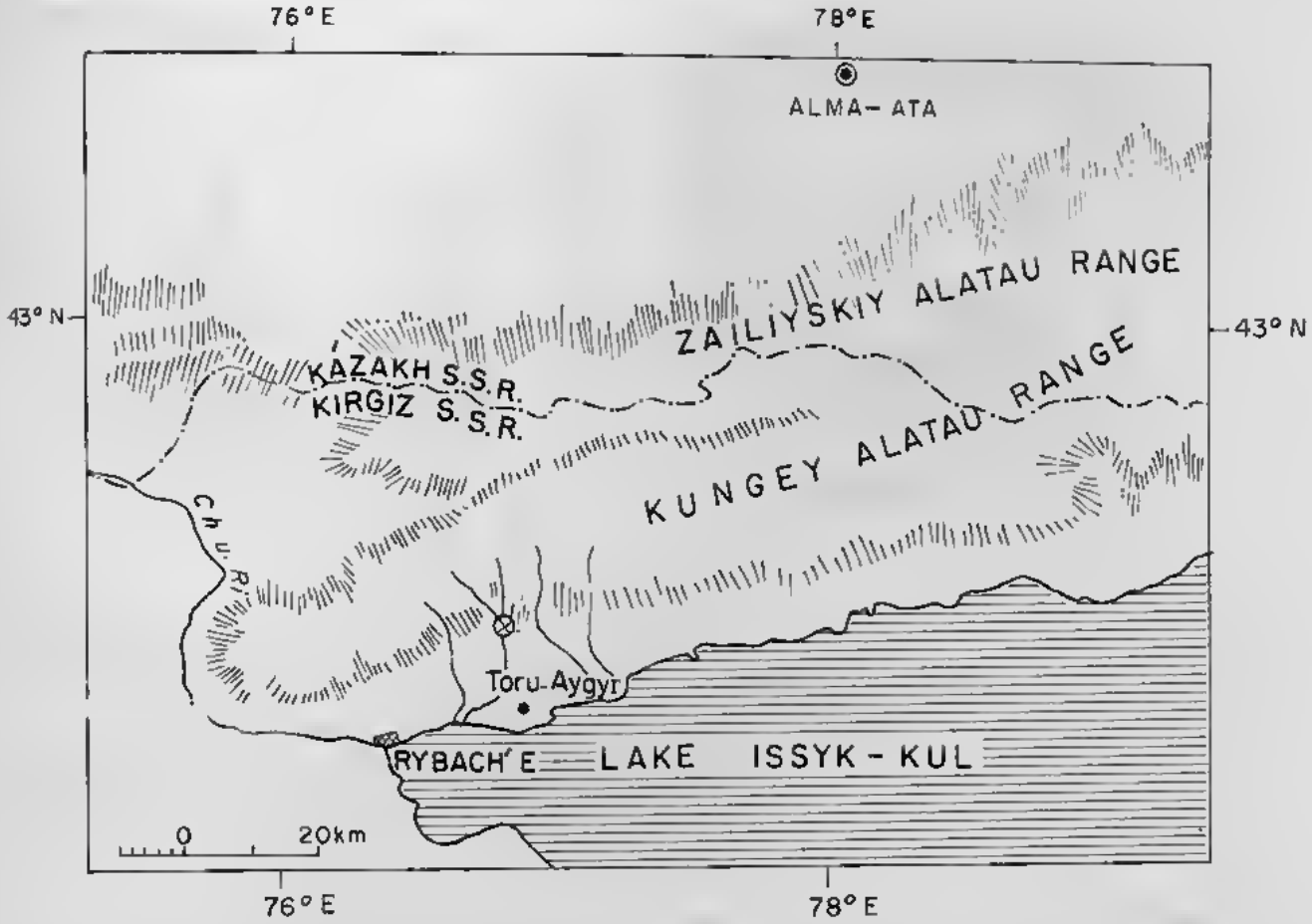


FIG. 113. — Regional map of the Issyk-Kul' Depression showing the locality of Toru-Aygyr at the southern base of the Kungey-Alalau range, Kazakh S.S.R. Modified from a map provided by G. V. Shkurkin.

thicknesses from 5 to 10 m. Higher up, olivine basalts are exposed, which to the west are interlayered with red bed silts up to 25 m thick. The basalts are again overlain with silts totaling more than 30 m and containing lenticular sandstones, gypsum and marly limestone.

The fossil locality is situated about 30 km from Rybach'e on the right bank of the Toru-Aygyr River (a stream, rather) 0.5 km west of the mouth of the Kuul'deka River, and occurs in the lower part of the formation. The section at this point is as follows:

1. arenaceous limestone	0.5 m to 2 m
2. coarse-grained, light gray sandstone	3.5 m
3. greenish gray clays, locally reddish buff with numerous bones	2 m
4. greenish gray sandstone of variable grain size with bone scrap	2 m
5. arenaceous clays, gypsiferous, reddish buff	more than 20 m

The Toru-Aygyr fauna has been correlated with that of Shinzhaly, Khaychin Ula II and III, Kholboldzhi and Irdin Manha, but some of the published evidence is uncertain. The two perissodactyl species named by Tarasov (1968), *Deperetella kungeica* and *Triplopus zhukovi*, but only briefly described, should perhaps be considered *nomina nuda* and ignored as they were by Reshetov (1979) in his revision of tapiroids. It is probable (according to Reshetov, pers. com., 1981) that *Triplopus zhukovi* is a synonym of *Teleolophus beliajevi* described from the probably contemporaneous fauna of Shinzhaly. Supporting this supposition is an upper jaw now known from Toru-Aygyr (and which is not the type specimen of *T. zhukovi*, whose whereabouts is

Source : MNHN, Paris

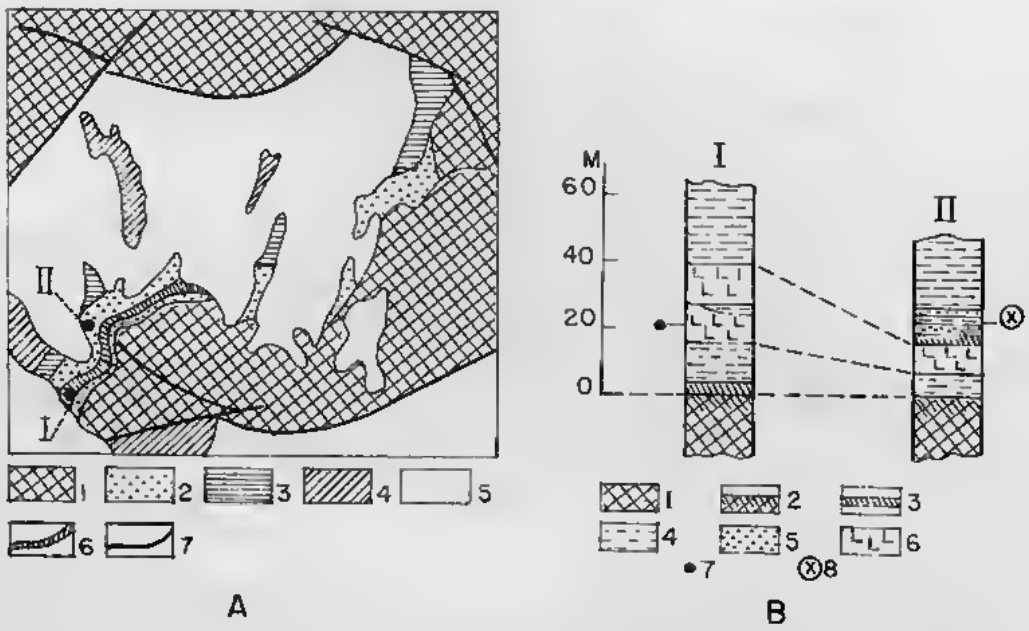


FIG. 114. — A, Schemalic geologic map of the Toru-Aygyr locality, Kazakh S.S.R. 1. early Paleozoic granites; 2. Chonkurchak Svita; 3. Usun Series (Dzhetyoguz Svita); 4. Neogene beds; 5. Quaternary beds; 6. faults; 7. basalt member. I. Place from which was taken a sample for radiometric dating. II. Mammal locality.

8. Sections taken at I, site of the dating sample, and II, at the mammal locality. 1. early Paleozoic granites; 2. weathering crust on granites; deposits of the Chonkurchak Svita; 3. chemogenic limestone; 4. clay beds; 5. sandstone; 6. basalt; 7. level at which the radiometric sample was taken; 8. fossiliferous level of the mammal locality. Modified from Nesmeyanov, Reshetov & Shmidt, 1977.

unknown to Reshetov) that is referable to *Teleolophus beliajevi*. From what is known of *Deperetella kungeica* it, too, could as easily be referred to *Teleolophus* (pers. com., Reshetov, 1981). If the identification of *Gobiatherium mirificum* is correct, which seems likely as the material is excellent, evidence for a middle Eocene age is suggested, as this taxon was previously restricted to the Arshanto Formation of Inner Mongolia. In reality, it is not possible to correlate with such accuracy. Reshetov (pers. com., 1981) considers the fauna to be not younger than the beginning of the late Eocene. We follow this opinion, and consider the locality as correlative with the Irdin Manha fauna.

Samples for radioisotopic dates were taken from various places in the basalts underlying the fossiliferous level by the Absolute Age Laboratory of the Geological Institute of the Academy of Sciences of the Georgian S.S.R.; all gave essentially the same age of 56 ± 3 MY. The fossil material was collected quite close to the basalt contact, as well as up to 4 m above it, but the presence of an unconformity between the two beds cannot be excluded. Correction by calculating the date with the decay constant now used in the West gives a younger age, but one that still indicates early Eocene on the Occidental scale (Eocene-Oligocene limit: 34-38 MY; middle-late Eocene limit: 39-42 MY; early-middle Eocene limit: 45-52 MY; late Paleocene-early Eocene limit; 52-58 MY). For the moment, analysis of the mammalian assemblage is the most reliable means of correlation.

Fauna of the Chonkurchak Svita at Toru-Aygyr

DINOCERATA

UINTATHERIIDAE

— *Gobiatherium mirificum* Osborn & Granger, 1932; cited by Nesmeyanov *et al.*, 1977

Source : MNHN, Paris

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Reshetov, 1975

DEPERETELLIDAE
— *Deperetella kungeica* Tarasov, 1968, *nomen nudum*?
— *Teleolophus beliajevi* Biryukov, 1975; cited by Reshetov, pers. com., 1981
— *Teleolophus* sp.; cited by Tarasov, 1968

LOPHIALETIDAE
— *Lophialetes expeditus* Matthew & Granger, 1925f; cited by Reshetov, 1975

HYRACODONTIDAE
— *Triplopus zhukovi* (Tarasov, 1968), *nomen nudum*
(= *Prothyracodon zhukovi* Tarasov, 1968)
("*Prothyracodon*" = *Triplopus in* Radinsky, 1967)

AMYNODONTIDAE Indet., cited by Reshetov, 1975

ARTIODACTYLA, Indet.; cited by Reshetov, pers. com., 1981.

Lat. 41° 2′ N, approx.
Long. 71° 50′ E, approx.

Fig. 3, n° 11

U.S.S.R.
UZBEK S.S.R.
Oshkaya Oblast'
Fergana Depression

Alay Svita **middle Eocene**

Locality: Mayli-Say

Another locality in the Fergana Depression, Mayli-Say[127], is present in the same marine beds that furnished Andarak 1 and II. This site is found in the northeastern part of the depression on the right bank of the Mayli-Say River, 2 km north of Mayli-Say Mountain. It is attributed to the lower level of the 12-14 m thick bed of green and variegated clay characterizing the middle part of the Alay Svita. It has so far yielded very little and poorly preserved mammalian material. The known remains are limited to large perissodactyl bones. Dmitriyeva and Nesmeyanov (1982) cite the presence of Brontotheriidae, as identified by Trofimov. Flerov *et al.*, 1974, for unstated reasons, considered the locality as slightly younger than those of Andarak 1 and II and correlated it with Shinzhaly.

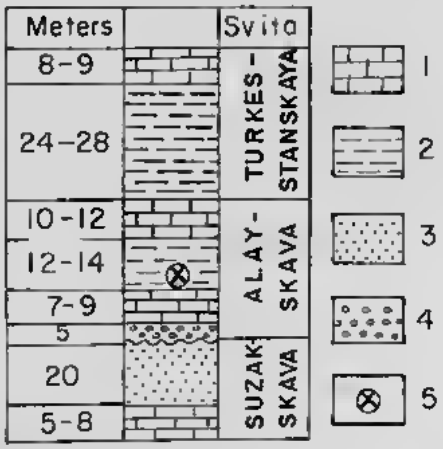


FIG. 115. — Section on the right bank of the Mayli-Say River between the villages of Mayli-Say and Kayragach, Uzbek S.S.R. 1. limestone; 2. clay; 3. sandstone; 4. conglomerate; 5. find locality. Modified from Dmitriyeva and Nesmeyanov, 1982

127 Mayli-Say = greasy ravine; greasy could refer to the presence of clay, or mean rich in the sense of many animals.

Source : MNHN, Paris

MIDDLE EOCENE

Composite List

(Ar: Arshanto; **Chk**: Chakpaktas; **Da**: Dacangfang; **Dj**: Dongjun; **Fer**: Fergana (Andarak); **Het**: Hetaoyuan; **Hbl**: Huhebolhe; **Ir**: Irdin Manha; **Jg**: Junggar; **Kch**: Kachchh; **Kdn**: Kuldana; **Khb**: Kholoboldzhi-Nur; **Ku**: Khaychin-Ula II, III, V; **Lan**: Lantian; **Lb**: Lingbao; **Lij**: Lijiang; **Lob**: lower Obayla; **Lu**: Lushi; **Mrg**: Mergen; **Mob**: middle Obayla; **Ping**: Pingchangguan; **Sg**: Sargamys; **Sub**: Subathu; **Szl**: Shinzhaly; **Ush**: Ulan Shireh; **Tor**: Toru-Aygyr; **Tuk**: Tukhum; **Uob**: Upper Obayla; **Wu**: Wucheng; **Yidu**: Yidu; **Xin**: Xintai. (Lumeiyi and Liankan not included)).

TAENIODONTA

STYLINODONTIDAE

Lu — *Stylinodon*? sp.

FAMILY Indet.

Het — *Chungchienia sichuanica*

INSECTIVORA

Ku APTERNODONTIDAE Indet.

FAMILY Indet.

Kdn — *Seia shahi*
Fer, Ku — Erinaceomorpha indet.
Sg, Lob — Insectivora indet.

PROTEUTHERIA

PANTOLESTIDAE

Khb — *Bogdia orientalis*
Ir — Pantolestidae indet.

FAMILY indet.

Kdn — *Pakilestes lathrius*

Kdn CHIROPTERA Indet.

PRIMATES

OMOMYIDAE

Kdn — *Kohatius coppensi*

Kdn ADAPIDAE Indet.

FAMILY Indet.

Lu — *Lushius qinlinensis*

PANTODONTA

PANTOLAMBDODONTIDAE

Ush — *Pantolambdodon inermis*
Khb — *Pantolambdodon bogdensis*
Ar — *Pantolambdodon* sp.
Khb — *Archaeolambda prima*

CORYPHODONTIDAE

Ir, Ush — *Eudinoceras mongoliensis*
Ar — *Eudinoceras luminus*
Xin — *Eudinoceras xintaiensis*
Dj — *Eudinoceras crassum*
Yidu — *Eudinoceras youngi*
Khb — *Eudinoceras kholobolchiensis*
Mob — *Eudinoceras obailiensis*
Jg, Lu — *Eudinoceras* sp.
Ku — cf. *Eudinoceras* sp.
Xin — "*Coryphodon*" *flerowi*

Source : MNHN, Paris

Da, Xin — Coryphodontidae indet.
Hbl, Lob — Pantodonta indet.

TILLODONTIA

TILLOTHERIIDAE

Xin — *Kuanchuanius shantunensis*
Kdn — *Basalina basalensis*
Ar — Tillotheriidae indet.

DINOCERATA

UINTATHERIIDAE

Ar, Tor — *Gobiatherium mirificum*
Ar — *Gobiatherium* sp.
Lu — *Uintatherium insperatus*
Xin, Mob — Uintatheriidae indet.

LAGOMORPHA

LEPORIDAE

Ush — *Shamolagus grangeri*
Lob — *Shamolagus ninae*
Lu — *Lushilagus lohoensis*
Ush — Palaeolaginae indet.
Kbh, Szl, Mrg, Ku, Fer — Lagomorpha indet.

RODENTIA

PARAMYIDAE

Lob — *Abrosomys agasma*
Lob — *Paramys obaylensis*
Ir, Hbl — Paramyidae indet.
Lob — Paramyidae? indet.

CTENODACTYLIDAE

Ku, Lob — *Saykanomys chalchae*
Chk — *Saykanomys* sp.
Fer, Ku, Lob — *Petrokozlovia notos*
Kdn — cf. *Petrokozlovia* sp.
Lob, Mob — *Tamquammys tantillus*
Ar — *Tamquammys wilsoni*
Fer — *Tamquammys* sp.
Hbl — *Advenimus burkei*
Ush — *Advenimus bohlini*
Ush — cf. *Advenimus* sp.
Lu — *Tsinlingomys youngi*
Ush — *Yuomys weijingensis*
Ping — *Yuomys minggangensis*
Wu — *Yuomys elegantes*
Mrg — *Yuomys* sp.
Kdn — *Birbalomys vandermeuleni*
Kdn — *Birbalomys ijlsti*
Kdn — *Birbalomys sondaari*
Kdn, Sub — *Birbalomys woodi*
Kdn, Sub — *Chapattimys debruijni*
Kdn — *Chapattimys wilsoni*
Kdn — *Gunbatomys asifi*
Lob — *Chkhikvadzomys elpisma*
Lob — *Bolosomys brachybamon*
Lob — *Geitonomys bouvites*
Hbl, Fer — "Paramyidae" indet.
Da — "Cocomyidae" indet.

Source : MNHN, Paris

Sg, Lob, Uob — "Chapattimyidae" indet.
Het — Ctenodactyloidea indet.
Mob "EOMYIDAE" indet.

PHIOMYIDAE?

Lob — *Bleutosomys dasikerkos.*

FAMILY Indet.

Lob — *Aksyiromys dalos*
Lob — *Ulkenulastomys abrotos*
Xin, Fer, Kdn, Szl — Rodentia indet.

MIXODONTIA

Sg FAMILY indet.

CARNIVORA

MIACIDAE

Ir — *Miacis invictis*
Lu, Het — *Miacis lushiensis*
Chk — cf. *Miacis* sp.
Mob — cf. *Vulpavus* sp.
Ush, Lob — Miacidae indet.

CANIDAE

Lu — *Cynodictis* sp.
Ush — cf. "*Cynodictis*" sp.

FELIDAE

Lu — cf. *Eusmilus* sp.
Dj — *Eusmilus*? sp.
Jg — Felidae indet.
Ar, Ping, Szl, Wu, Tuk — Carnivora indet.

CREODONTA

OXYAENIDAE

Ush — *Sarkastodon mongoliensis*
Het — *Prolaena parva*

HYAENODONTIDAE

Ir, Lu — *Propterodon morrisi*
Ush — cf. *Propterodon morrisi*
Lb — cf. *Propterodon* sp.
Ku — *Pterodon rechetovi*
Lu, Wu — *Hyaenodon* sp.
Xin — *Thinocyon*? *sichowensis*
Sub — *Paratritemnodon indicus*
Het — "*Sinopa*" sp.
Het — *Tritemnodon* sp.
Lij, Wu — Hyaenodontidae indet.
Lob — cf. Proviverrinae indet.
Szl, Lij — Creodonta indet.

CONDYLARTHRA

ARCTOCYONIDAE

Ir, Hbl, Lu — *Andrewsarchus mongoliensis*
Dj — *Andrewsarchus crassum*
Het — *Andrewsarchus*? sp.
Lu — *Paratriisodon henanensis.*

MESONYCHIDAE

Ir — *Hapalodectes serus*
Ush — *Hapalodectes serus*?
Ar — *Mesonyx*? sp.

Source : MNHN, Paris

Ush, Ir	— cf. *Mesonyx* sp.
Ush	— *Harpagolestes*? *orientalis*
Mrg	— *Harpagolestes*? *orientalis*?
Ir	— cf. *Pachyaena* sp.
Hbl	— *Mongolonyx dolichognathus*
Ku	— *Mongolonyx robustus*
Ar	— *Mongolonyx* sp.
Lu, Lij	— *Honanodon hebetis*
Lu	— *Honanodon macrodontus*
Lij	— *Honanodon* sp.
Sub	— cf. *Honanodon* sp.
Lu	— *Lohoodon lushiensis*
Ku	— *Metahapalodectes makhchinus*
Da, Ir, Sg	— Mesonychidae indet.
Fer, Lob	— Condylarthra indet.

PERISSODACTYLA

BRONTOTHERIIDAE

Ir	— *Metatelmatherium parvum*
Hbl	— *Metatelmatherium cristatum*
Dj	— *Metatelmatherium* sp.
Ir, Ush, Ku	— *Microtitan mongoliensis*
Ar	— *Microtitan* sp.
Ar, Lu	— *Microtitan*? sp.
Lan	— *Arctotitan honghoensis*
Ush	— *Acrotitan ulanshirehensis*
Ir	— *Gnathotitan berkeyi*
Hbl	— *Protitan minor*
Usb	— *Protitan bellus*
Ir	— *Protitan obliquidens*
Ku	— *Protitan khaitshinus*
Ku	— *Protitan reshetovi*
Ir, Lu	— *Protitan grangeri*
Hbl	— *Protitan*? *cingulatus*
Dj	— cf. *Protitan* sp.
Het	— *Protitan*? sp.
Ush	— *Desmatotitan tukhumensis*
Ar	— *Desmatotitan* sp.
Ir	— *Epimanteoceras robustus*
Ush	— *Epimanteoceras formosus*
Ush	— *Dolichorhinoides angustidens*
Da	— cf. *Palaeosyops* sp.
Xin, Lob	— *Palaeosyops* sp.
Kdn	— *Pakotitanops latidentatus*
Kdn	— *Eotitanops dayi*
Sub	— *Mulkrajanops moghliensis*
Lh, Lij, Khb, Szl, Tor	— Brontotheriidae indet.

EQUIDAE

Xin	— *Propalaeotherium sinense*
Xin	— *Propalaeotherium* sp.
Khb	— *Gobihippus menneri*
Xin	— Hyracotheriinae? indet.

EOMOROPIDAE

Wu, Lu, Lij	— *Eomoropus* sp.
Hbl	— *Litolophus gobiensis*
Xin	— *Grangeria canina*

Source : MNHN, Paris

Fer	CHALICOTHERIIDAE Indet.
	CHALICOTHERIIDAE?
Lu	— *Lunania youngi*
	ISECTOLOPHIDAE
Sub	— *Sastrilophus dehmi*
Chk	— cf. *Homogalax* sp.
Lob, Khb	— Isectolophidae indet.
	DEPERETELLIDAE
Ir, Ku	— *Teleolophus medius*
Hbl	— cf. *Teleolophus medius*
Ush	— *Teleolophus medius*?
Mob	— *Teleolophus* cf. *medius*
Het	— *Teleolophus danjiangensis*
Szl, Tor	— *Teleolophus beliajevi*
Ar, Xin, Tor, Ku, Dj, Lij	— *Teleolophus* sp.
Kdn	— *Teleolophus*? *daviesi*
Xin	— *Teleolophus*? *shandongensis*
Dj	— *Diplolophodon* cf. *similis*
Het	— *Pachylophus xui*
Ku	— *Deperetella khaitchinulensis*
Fer	— *Deperetella ferganica*
Het	— *Deperetella sichuanensis*
Tor	— *Deperetella kungeica*
Wu, Lu, Lij	— *Deperetella* sp.
Mob, Uob, Lan	— cf. *Deperetella* sp.
	HELALETIDAE
Ir	— *Helaletes mongoliensis*
Mob	— *Helaletes* cf. *mongoliensis*
Hbl	— *Helaletes fissus*
Hbl	— *Helaletes fissus*?
Chk	— *Helaletes* n. sp.
Hbl, Xin	— *Helaletes* sp.
Xin	— *Hyrachyus metalophus*
Sub	— *Hyrachyus asiaticus*
Kdn	— cf. *Hyrachyus asiaticus*
Lb, Ar, Xin	— *Hyrachyus* sp.
Xin	— *Hyrachyus modestus*?
Hbl	— cf. *Hyrachyus* sp.
Mob	— *Veragromovia desmatotheroides*
Mob	— cf. *Veragromovia* sp.
Ar	— *Colodon* cf. *inceptus*
Lu	— *Colodon* sp.
Chk, Lob, Sg	— Helaletidae indet.
	LOPHIALETIDAE
Ar, Ir, Tor, Mrg, Ku, Hbl, Jg	— *Lophialetes expeditus*
Ush, Khb	— *Lophialetes expeditus*?
Mob	— *Lophialetes* cf. *expeditus*
Tuk	— *Lophialetes* cf. *expeditus*?
Mob, Ush, Da, Het, Xin, Lu	— *Lophialetes* sp.
Ir	— *Lophialetes*? sp.
Ir, Ush, Lu, Xin, Ku, Mrg, Het	— *Breviodon minutus*
Ping, Het, Lob, Ar	— *Breviodon* cf. *minutus*
Lan, Wu, Szl, Lij, Khb	— *Breviodon* sp.
Usb, Hbl	— *Breviodon*? sp.
Szl	— *Eoletes gracilis*
Ir	— *Simplaletes sujiensis*

Source : MNHN, Paris

Ush	— *Simplaletes ulanshirehensis*
Het	— *Schlosseria hetaoyuanensis*
Ar	— *Schlosseria magister*
Ush	— *Schlosseria* cf. *magister*
Hbl	— cf. *Schlosseria magister*
Xin, Khb, Ar, Lij	— *Schlosseria* sp.
Ush	— *Zhongjianoletes chowi*
Ush	— *Zhongjianoletes*? sp.
Kdn, Sub	— *Kalakotia simplicidentata*
Wu, Sg	— Lophialetidae indet.
LOPHIALETIDAE?	
Ir, Ush	— *Rhodopagus pygmaeus*
Lob	— *Rhodopagus* cf. *pygmaeus*
Xin	— *Rhodopagus zdanskyi*
Ush	— *Rhodopagus minimus*
Xin	— *Rhodopagus laiwuensis*
Fer	— *Rhodopagus minutissimus*
Chk, Lob	— *Rhodopagus* aff. *minutissimus*
Kbb, Szl, Chk, Mob	— *Rhodopagus* sp.
Lob	— cf. *Rhodopagus* sp.
Fer	— *Pataecops microdon*
Khb	— *Pataecops parvus*
HYRACODONTIDAE	
Ir, Ush, Mrg, Ku	— *Triplopus*? *proficiens*
Ping	— *Triplopus*? cf. *proficiens*
Sub	— *Triplopus kalakotensis*
Mob	— *Triplopus* cf. *implicatus*
Sg, Uob	— *Triplopus chkhikvadzei*
Tor	— *Triplopus zhukovi*
Chk, Lob	— *Triplopus* sp.
Hbl	— *Forstercooperia grandis*
Ar	— *Forstercooperia grandis*?
Usb, Mob	— *Forstercooperia* cf. *grandis*
Ir, Ku	— *Forstercooperia totadentata*
Ar, Dj, Fer, Lu, Sg, Uob	— *Forstercooperia* sp.
Ar	— *Urtinotherium*? n. sp.
Wu	— *Pappaceras* sp.
Het, Dj, Szl, Lu, Lij, Mob, Sg	— *Prohyracodon* sp.
Ping, Sg	— Hyracodontidae indet.
Ping, Tuk	— Rhinocerotoidea indet.
HYRACODONTIDAE?	
Sub	— "*Forstercooperia*" *jigniensis*
AMYNODONTIDAE	
Wu	— *Sharamynodon mongoliensis*
Ush	— *Lushiamynodon sharamurenensis*
Lu	— *Lushiamynodon menchiapuensis*
Wu	— *Lushiamynodon wuchengensis*
Fer	— *Lushiamynodon*? *kirghisiensis*
Fer	— *Lushiamynodon*? sp.
Da	— *Caenolophus minimus*
Lu, Lob, Lij	— *Caenolophus* sp.
Lob	— cf. *Caenolophus* sp.
Lu	— *Sianodon honanensis*
Wu	— *Sianodon sinensis*
Het	— *Sianodon* sp.
Dj	— *Ilianodon*? sp.

Source : MNHN, Paris

Tuk	— *Teilhardia pretiosa*
Khb	— *Teilhardia*? sp.
Hbl	— *Rostriamynodon grangeri*
Dj	— cf. *Gigantamynodon* sp.
Lij	— *Amynodon* sp.
Dj	— cf. *Paramynodon* sp.
Ku, Tor	— Amynodontidae indet.

ARTIODACTYLA

DICHOBUNIDAE

Kdn	— *Chorlakkia hassani*
Kdn	— *Dulcidon gandaensis*
Kdn	— *Diacodexis pakistanensis*
Lu	— *Dichobune* sp.
Chk	— Dichobunidae nov.
Fer, Kdn, Lob, Sub	— Dichobunidae indet.

ENTELODONTIDAE

Lij	— *Eoentelodon "likiangensis"*

ANTHRACOTHERIIDAE

Lu	— *Anthracotherium*? sp.
Dj	— *Probrachyodus*? sp.
Lij, Ping	— *Anthracokeryx* sp.
Kdn	— cf. *Anthracokeryx* sp.
Lij	— *Anthracothema* sp.
Ping	— Anthracotheriidae

LEPTOMERYCIDAE

Szl	— *Archaeomeryx* sp.
Ir	— cf. *Archaeomeryx* sp.
Lij	— Leptomerycidae? indet.

RAOELLIDAE

Kdn, Sub	— *Khirtharia dayi*
Sub, Kdn	— *Haqueina haquei*
Sub	— *Indohyus indirae*
Kdn	— *Indohyus* cf. *indirae*
Sub	— *Metkatius kashmiriensis*

HELOHYIDAE

Ir, Ping, Ush, Lu	— *Gobiohyus orientalis*
Kdn	— *Gobiohyus* cf. *orientalis*
Ir	— *Gobiohyus pressidens*
Ir, Lu	— *Gobiohyus robustus*
Ku, Mrg	— *Gobiohyus* sp.
Ping	— *Gobiohyus*? *minor*

FAMILY Indet.

Lob	— *Aksyiria oligostus*
Uob, Lob	— *Paraphenacodus solivagus*
Uob	— *Paraphenacodus* cf. *solivagus*
Tor	— Artiodactyla indet.

PROBOSCIDEA

ANTHRACOBUNIDAE

Kdn, Sub	— *Pilgrimella pilgrimi*
Kdn	— *Anthracobune pinfoldi*
Sub	— *Anthracobune* sp.
Kdn	— *Lammidhania wardi*
Kdn	— *Jozaria palustris*

Source : MNHN, Paris

MOERITHERIIDAE

Kch — cf. Moeritheriidae

CETACEA

PROTOCETIDAE

Kdn — *Ichthyolestes pinfoldi*
Kdn — *Gandakasia potens*
Kdn — *Pakicetus inachus*
Kdn — *Pakicetus attocki*
Kch — *Indocetus ramani*
Kch — *Protocetus sloani*
Kch — *Protocetus harudiensis*

AGOROPHIDAE

Kch — *Andrewsiphius kutchensis*
Kch — *Andrewsiphius minor*

SIRENIA

PROTOSIRENIDAE

Kch — *Protosiren fraasi*

ORDER Indet.

DIDYMOCONIDAE

Ir — *Mongoloryctes acutus*

DIDYMOCONIDAE?

Ush — *Kennatherium shirensis*

FAMILY Indet.

Xin — *Heptaconodon dubium*

Lat. 21° 30′ - 22° N, approx.
Long. 94° 30′ - 94° 45′ E, approx.

BURMA

MONYWA DISTRICT

Pale Township

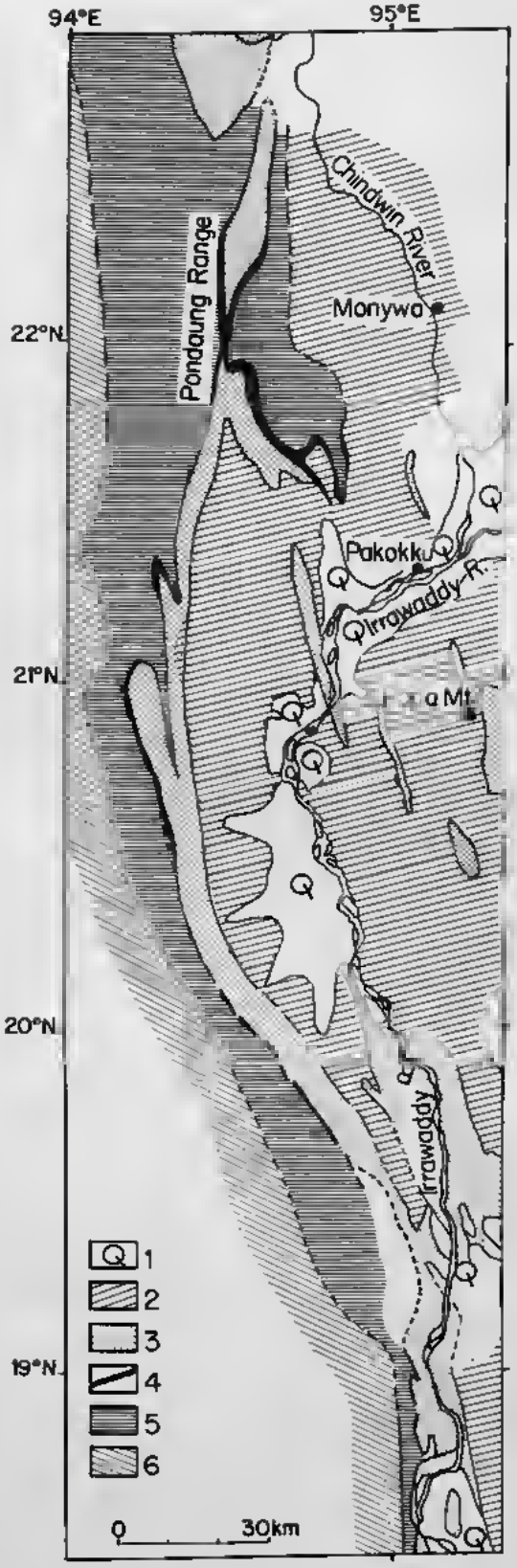
Pondaung Sandstone **late Eocene**

Localities: vicinity of Mogaung

The presence of Tertiary fossils in the strata along the Irrawaddy River was first indicated in print as early as 1828, but the early Tertiary fauna of the Pondaung beds was not made known until the work of Pilgrim and Cotter in 1915. An American Museum party collected in the latter formation in 1923, assembling a collection that was described by Colbert (1938), during a revision of the total known fauna. Little field work has been done since the first quarter of the century, although teams from both the University of Mandalay and the University of California have made forays during the 1970's and 1980's.

The fossiliferous rocks of the Pondaung Formation are the result of continental river and delta deposits filling in the gulf of a vacillating but southward retreating sea. The Pondaung Sand-

Source : MNHN, Paris



stone is situated near the top of the Eocene sequence in middle and northern Burma. A maximum thickness of over 2,000 m is recorded; it is underlain by either the Tabyin Clay or the Tilin Sandstone, and overlain by the Yaw Stage, an interfingering marine deposit, or in the north, by the freshwater Pegu Series. The lower part of the Pondaung Sandstone is comprised of greenish sandstone, with bands of conglomerate and greenish shale; conformably overlying this sequence is a 17 m thickness of brilliantly colored clay, in hues of red, blue and yellowish white, of continental origin. This upper part alone yielded vertebrate fossils.

Except for a confused abundance of anthracotheres, the Pondaung assemblage is quite incomplete and, consequently, rather difficult to correlate. Virtually no genera (*Metatelmatherium*?) are shared with the faunas of Inner Mongolia. The three forms, *Anthracokeryx*, *Anthracothema* and *Diplolophodon*, that are present in both the Pondaung and the Heti faunas suggest for the former a late Eocene age, as the fauna of the Heti Formation (of the Yuanqu Basin) is considered a firm correlative of the Shara Murun assemblage. To date, there is no better evidence to indicate an older age.

The interfingering marine beds above and below the Pondaung Sandstone corroborate its Eocene age. The Tabyin is characterized by *Nummulites acutus*, but is generally poorly fossiliferous. It is assumed to correlate with the Khirthar Stage of Pakistan. The overlying Yaw Shales have been dated by macroforaminifera that indicate a late Eocene age. Bender (1983) regards the Pondaung Sandstone as middle to late Eocene and states that the Eocene-Oligocene boundary lies within the Shwezetaw Sandstone, well above the Pondaung Formation.

FIG. 116. Geological sketch map of part of the Tertiary region of Burma. **1.** Quaternary; **2.** Irrawadian sediments (Miocene-Pleistocene); **3.** Pegu Series (Eocene-Oligocene); **4.** Yaw Stage (late Eocene); **5.** Eocene sediments; **6.** pre-Tertiary sediments. Modified from Stamp, 1922.

Source : MNHN, Paris

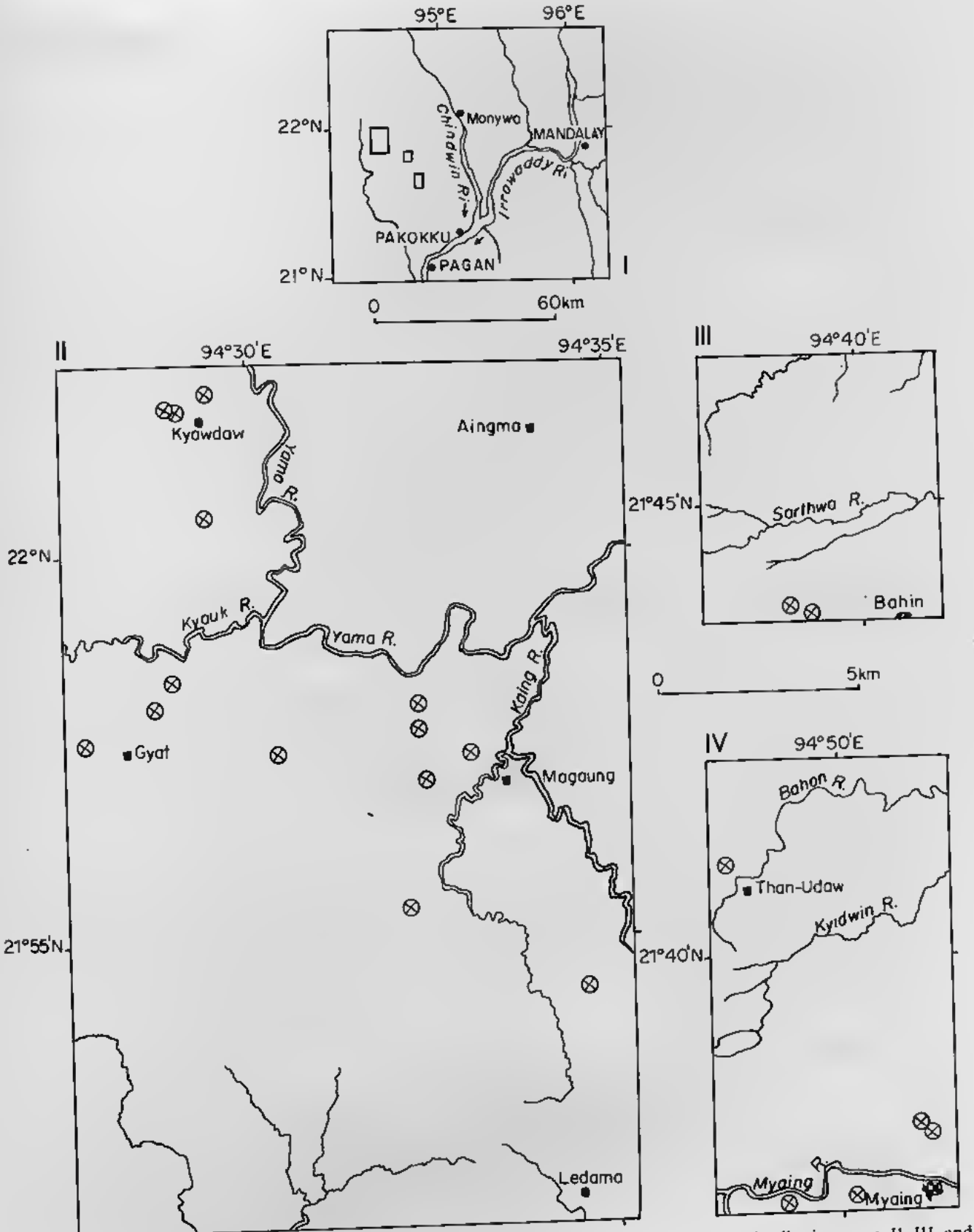


FIG. 117. — I, Map of the region west of Mandalay, Burma, showing the location of the principal collecting areas. II, III, and IV. Detailed maps showing the fossil mammal localities. Modified from Colbert, 1938.

Source : MNHN, Paris

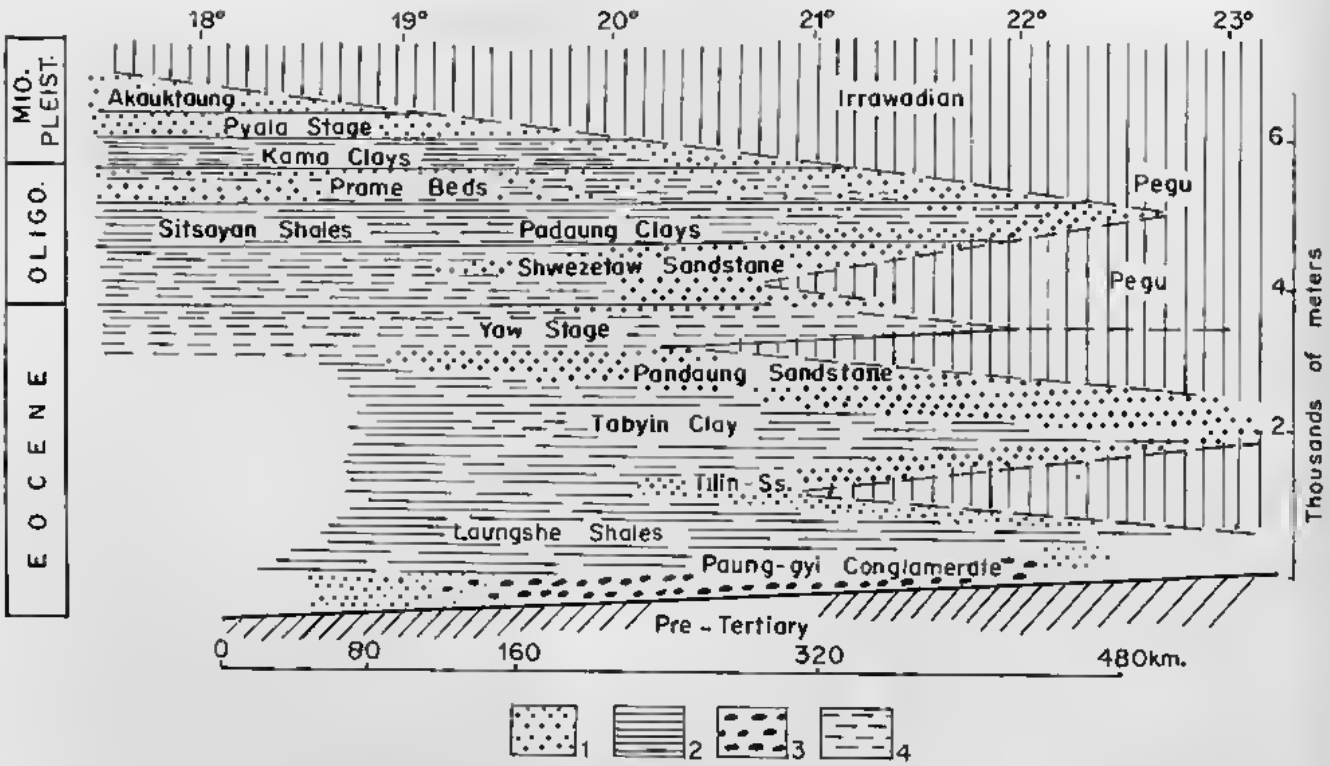


FIG. 118. — Diagram showing the relationships of the Cenozoic sediments of Burma, from south to north. **1**. sand; **2**. clay; **3**. conglomerate; **4**. shales. Modified from Stamp, 1922.

Fauna of the Pondaung Sandstone

PRIMATES

FAMILY Indet.
- — *Pondaungia cotteri* Pilgrim, 1927
- — *Amphipithecus mogaungensis* Colbert, 1937

CARNIVORA

VIVERRIDAE? Indet.; cited by D. E. Savage, pers. com., 1980

PERISSODACTYLA

BRONTOTHERIIDAE
- — *Sivatitanops cotteri* Pilgrim, 1925
- — *Sivatitanops birmanicum* (Pilgrim & Cotter, 1916) Colbert, 1938
  (= *Telmatherium? birmanicum* Pilgrim & Cotter, 1916)
- — *Sivanatitops? rugosidens* Pilgrim, 1925
- — *Metatelmatherium? browni* Colbert, 1938
- — *Metatelmatherium? lahirii* (Pilgrim, 1925), Colbert, 1938
  (= *Eotitanotherium? lahirii* Pilgrim, 1925)

DEPERETELLIDAE
- — *Diplolophodon birmanicum* (Pilgrim, 1925) Ding *et al.*, 1977, V.P. (1)
  (= *Chasmotherium? birmanicum*, Pilgrim, 1925)
  (= *Deperetella? birmanicum* (Pilgrim, 1925) Colbert, 1938)
  (= *Deperetella birmanicum* (Pilgrim, 1925) Radinsky, 1965)

TAPIROID Indet.
- — *Indolophus guptai* Pilgrim, 1925

AMYNODONTIDAE
- — *Paramynodon birmanicum* (Pilgrim & Cottert, 1916) Colbert, 1938
  (= *Metamynodon birmanicum* Pilgrim & Cotter, 1916)
- — *Paramynodon cotteri* (Pilgrim, 1925) Colbert, 1938
  (= *Metamynodon cotteri* Pilgrim, 1925)

Source : MNHN, Paris

ARTIODACTYLA

ANTHRACOTHERIIDAE

— *Anthracohyus choeroides* Pilgrim & Cotter, 1916
— *Anthracothema pangan* (Pilgrim & Cotter, 1916) Pilgrim, 1928
(= *Anthracotherium pangan* Pilgrim & Cotter, 1916)
(= *Anthracohyus rubricae* Pilgrim & Cotter, 1916, *in parte, in* Pilgrim, 1928
(= *Anthracothema palustre* (Pilgrim & Cotter, 1916), *in* Pilgrim, 1928
(= *Anthracohyus palustris* Pilgrim & Cotter, 1916 (*A. palustre* is probably synonymous with *A. pangan, in* Colbert, 1938))
(= *Anthracothema crassum* (Pilgrim & Cotter, 1916), *in parte, in* Pilgrim, 1928)
(= *Anthracotherium crassum* Pilgrim & Cotter, 1916, *in parte, in* Pilgrim, 1928)
(= *Anthracotherium crassum* Pilgrim & Cotter, 1916 (*A. crassum* is perhaps synonymous with *A. pangan, in* Colbert, 1938))
— *Anthracothema rubricae* (Pilgrim & Cotter, 1916) Pilgrim, 1928
(= *Anthracohyus rubricae* Pilgrim & Cotter, 1916)
— *Anthracokeryx moriturus* Pilgrim, 1928
— *Anthracokeryx birmanicus* Pilgrim & Cotter, 1916
(= *Anthracokeryx hospes* Pilgrim, 1928) (*A. hospes* is probably synonymous with *A. birmanicus, in* Colbert, 1938)
(= *Anthracokeryx bambusae* Pilgrim, 1928) (*A. bambusae* is probably synonymous with *A. birmanicus* or *A. tenuis, in* Colbert, 1938)
— *Anthracokeryx tenuis* Pilgrim & Cotter, 1916
(= *Anthracokeryx myaingensis* Pilgrim, 1928) (*A. myaingensis* is probably synonymous with *A. tenuis, in* Colbert, 1938)
(= *Anthracokeryx ulnifer* Pilgrim, 1928 (*A. ulnifer* is probably synonymous with *A. tenuis, in* Colbert, 1938)
— *Anthracokeryx? lahirii* Pilgrim, 1928

TRAGULOIDAE (*fide* D. E. Savage, pers. com., 1987)

— *Indomeryx cotteri* Pilgrim, 1928
— *Indomeryx arenae* Pilgrim, 1928

Lat 39° 49′ N
Long. 116° 14′ E

Fig. 2, n° 5

CHINA

BEIJING CITY

Changxindian

Changxindian Fm. **Late Eocene**

Changxindian[1] is a suburb of Beijing; politically, the latter is not a part of Hebei Province.

The Changxindian Formation (also called the Chansintien Gravels, named by Hsieh, 1933) is a thick series (100 m) of tilted conglomerates and red clays cropping out sporadically in the vicinity of Changxindian, some 20 km southwest of Beijing. The age of this formation has been discuss-

1 Changxindian = Changxin (place name) inn.

Source : MNHN, Paris

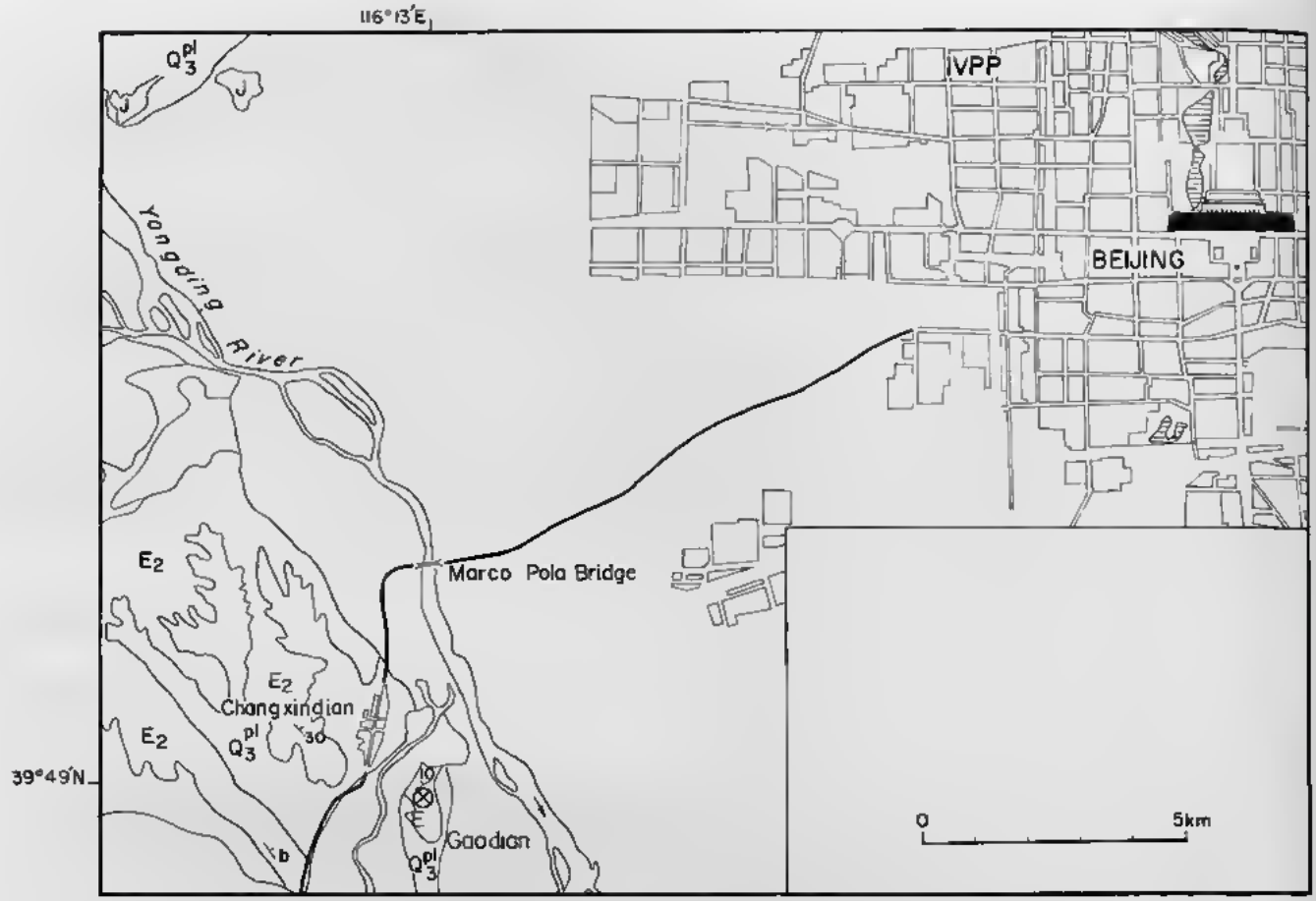


FIG. 119. — Map showing the location of the Changxindian fossil mammal site (and, incidentally, that of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Beijing). J: Jurassic; E_2: late Eocene Changxindian Formation; Q_3: late Pleistocene pluvial deposits. Map provided by Zhai R.-j.

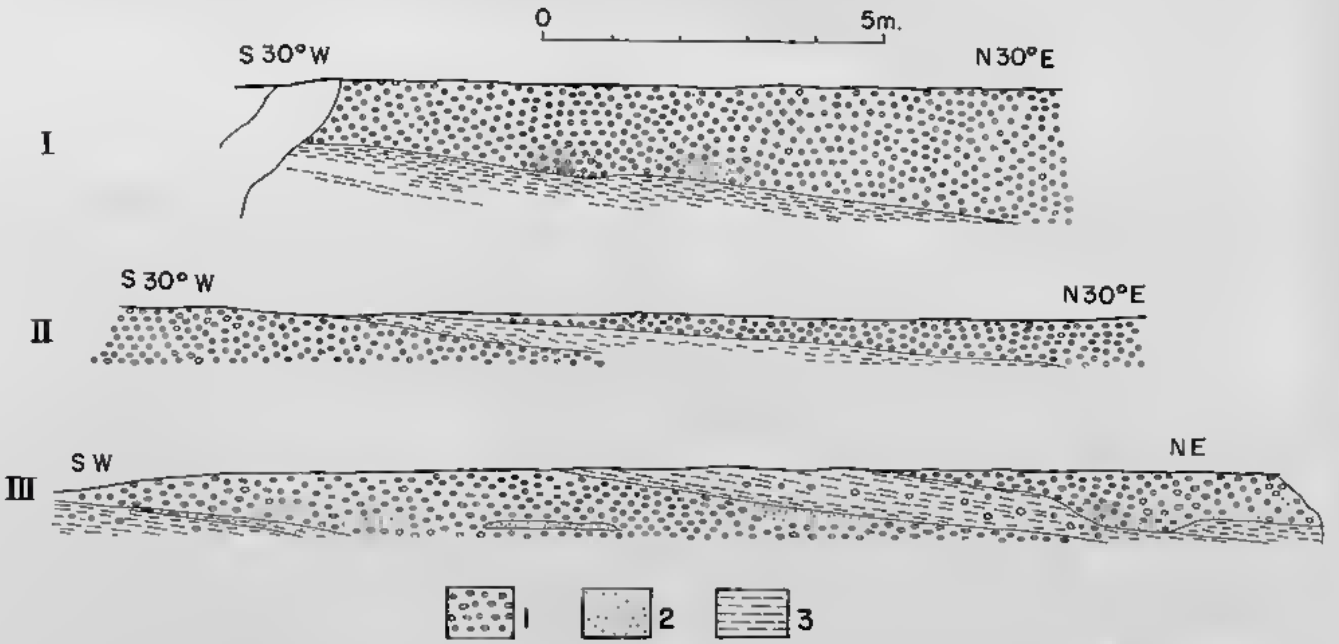


FIG. 120. — Cross sections taken through the Changxindian Fm. at the Changxingian Station yard, Beijing. 1. gravel; 2. sand; 3. clay. Modified from Andersson, 1923.

Source : MNHN, Paris

ed for more than half a century (Andersson, 1923; Young, 1934; Chow, 1953). In 1976 a small collection was made by IVPP members at Gaodian, 1 km southeast of Changxindian. On the basis especially of these fossils a late Eocene age is tentatively assigned to the fossil-bearing beds.

Quaternary sediments unconformably overlie the Changxindian Formation: the formation underlying it is not known.

Fauna of the Changxindian Fm.

INSECTIVORA
- ERINACEIDAE — *Tupaiodon*? sp.; cited by Chow, 1953

PANTODONTA
- CORYPHODONTIDAE — *Eudinoceras*? sp.; cited by Chow, 1953

MIXODONTIA
- EURYMYLIDAE — *Hypsimylus beijingensis* Zhai, 1977b, V.P. (3)

CARNIVORA
- MIACIDAE — *Miacis* sp.; cited by Zhai, 1977b, V.P. (3)
- CANIDAE Indet.; cited by Zhai, 1977b, V.P. (3)

PERISSODACTYLA
- HYRACODONTIDAE — *Imequincisoria* sp.; cited by Zhai, 1977, V.P. (3)
- AMYNODONTIDAE? Indet.; cited by Chow, 1953

Lat. 38° 47′ N
Long. 114° 38′ E

Fig. 2, n° 37

CHINA
HEBEI PROVINCE
(Hopeh)

unknown formation **late Eocene**

locality: Quyang

The only known early Tertiary mammal locality in Hebei Province is Quyang[2]. It is located on the east piedmont of the Taihangshan (mountains) and was discovered by regional geologists. No details concerning the locality are known to the staff of the IVPP; it was briefly mentioned by Chow, 1961, V.P. (3), p. 286, in "Notes and Activities". The fossils from Quyang have not been described, although amynodontids are known to occur there (mentioned by Xu, 1966).

2 Quyang (= Chuyang) = north of Qu River.

Source : MNHN, Paris

Lat. 35° 08′ N
Long. 112° 35′ E
(Jiyuan City)

Fig. 2, n° 8

CHINA
HENAN PROVINCE
(Honan)
Jiyuan Basin

Jiyuan formation **late Eocene**
Locality: Dongzhangcun[3]

The Jiyuan[4] Basin is situated in north Henan, in the northeastern part of the Yuanqu Basin. In 1963 an IVPP team, with the principal purpose of collecting fossil fishes, recovered Eocene mammals there. Field work has not been resumed since then.

The early Tertiary rocks in the basin may be divided lithologically into three parts: the lower part, which reposes unconformably on Jurassic sandstones, consists of thick-layered conglomerates; the middle part is made up of brownish sandstones and sandy mudstones containing gravels; the upper part, a brick red mudstone, crops out partially. It is overlain by Quaternary deposits. The total thickness of these rocks varies from about 400 m to 500 m. Vertebrate fossils occur only in the lower and middle parts of the section.

The few mammals known from the Jiyuan Basin show that the faunule may be contemporary with the fauna of the neighboring Yuanqu Basin. It has the amynodont species *Sianodon sinensis* in common with the latter and *Yuomys cavioides* occurs in both the Heti and the Shara Murun faunas.

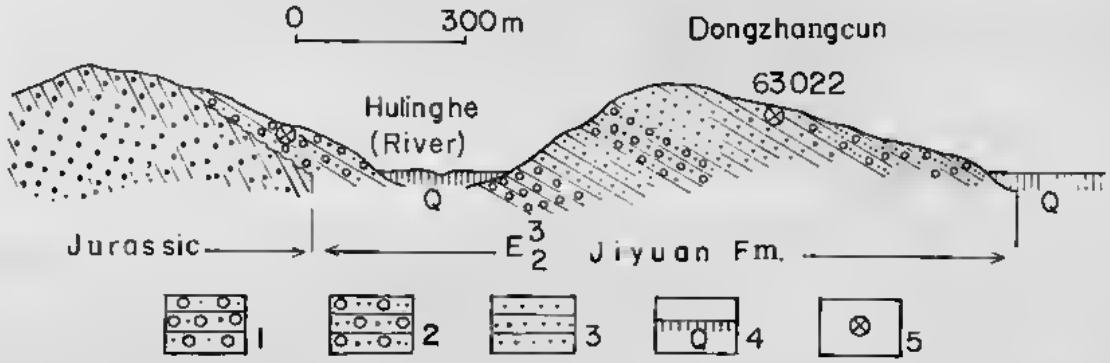


FIG. 121. — Cross section taken in the region of Dongzhangcun, Jiyuan Basin, Henan, showing the late Eocene fossiliferous Yiyuan Formation. **1**. conglomerate; **2**. gravelly sandstone; **3**. sandstone; **4**. Quaternary covering; **5**. fossil mammal locality. Modified from Chow *et al.*, 1973.

Fauna of Jiyuan Fm.

RODENTIA
CTENODACTYLIDAE[5] — *Yuomys cavioides* Li, 1975, V.P. (1)

PERISSODACTYLA
AMYNODONTIDAE — *Lushiamynodon obesus* Chow & Xu, 1965, V.P. (2); cited by Chow *et al.*, 1973, V.P. (2)

3 Dongzhangcun (= Tungchang): Dong = east; Zhang (= family name) village.
4 Jiyuan (= Chiyuan), county name.
5 See footnote n° 11, p. 77.

Source : MNHN, Paris

— *Sianodon chiyuanensis* Chow & Xu, 1965; cited by Chow *et al.*, 1973, V.P. (2)
— *Sianodon sinensis* (Zdansky, 1930) Chow & Xu, 1965; cited by Chow *et al.*, 1973
(= *Amynodon sinensis* Zdansky, 1930)

Lat. 34° 34′ N
Long. 110° 42′ E
(Lingbao City)

Fig. 2, n° 10

CHINA
HENAN PROVINCE
(Honan)
Lingbao Basin

Hunshuihe Fm. **late Eocene**

The sediments of the Lingbao Basin were discussed in the middle Eocene section. The uppermost formation, and that containing most of the fossils in the basin, is the Hunshuihe Fm. It can be divided lithologically into three levels; the highest one consists of grayish green and brown clay and sands; the middle is grayish brown sandy clays and sandstone with grayish green and brown clay; the bottom level is red-brown clay and sand. This formation is over 200 m thick and is overlain by loess.

The faunal list of the Hunshuihe Fm. indicates that it is probably late Eocene in age, but the material has not yet been thoroughly studied.

Fauna of the Hunshuihe Fm.

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Tong & Wang, 1980, V.P. (1)

AMYNODONTIDAE
— *Caenolophus* sp.; cited by Tong & Wang, 1980, V.P. (1)
— Amynodontidae indet.; cited by Tong & Wang, 1980, V.P. (1)

ARTIODACTYLA

ANTHRACOTHERIIDAE Indet.; cited by Tong & Wang, 1980, V.P. (1)

LEPTOMERYCIDAE — *Archaeomeryx* sp.; cited by Tong & Wang, 1980, V.P. (1)

Source : MNHN, Paris

Lat. 34° 04′ N
Long. 110° 02′ E
(Lushi City)

Fig. 2, n° 11

CHINA
HENAN PROVINCE
(Honan)
Lushi Basin

Chugouyu Fm. **late Eocene**

For more details on the Lushi Basin, consult the paragraphs written under the heading of the Lushi Formation.

The Chugouyu[6] Formation was recognized in the Lushi Basin by Tong and Wang during their field work there in 1979. It is characterized by multicolored clay, sandy clay and marls; at the top of the formation there is lignite. Formational thickness is 700 m; it is overlain by the (unfossiliferous) Dayu Formation of supposed Oligocene age; the Lushi Formation underlies the Chugouyu Formation.

Correlation of the formation is made with that of Shara Murun, mainly based on the mutual presence of *Litolophus major* and *Archaeomeryx optatus*. This is another case in China where, outside of Inner Mongolia, a Shara Murun-like fauna overlies a Irdin Manha-like (Lushi) fauna.

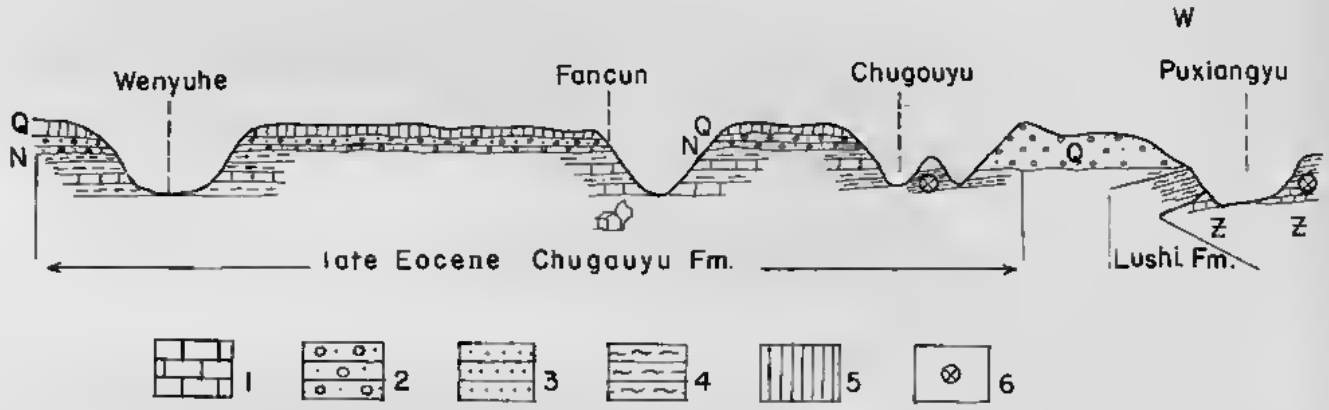


FIG. 122. — Cross section taken between the Wenyuhe and Puxiangyu, Lushi Basin, Henan, showing the relationship between the late Eocene Chugouyu Fm. and the underlying Lushi Fm. Q, Quaternary; N, Neogene (Pliocene gravels); Z, Precambrian limestone. **1**. marlite; **2**. conglomerate; **3**. sandstone; **4**. mudstone; **5**. loess; **6**. fossil mammal locality. Modified from Tong & Wang, 1980.

Fauna of the Chugouyu Fm.

LAGOMORPHA

LEPORIDAE — Palaeolaginae indet.; cited by Tong & Wang, 1980, V.P. (1)

RODENTIA

CTENODACTYLIDAE[7] — *Yuomys* n. sp.; cited by Tong & Wang, 1980, V.P. (1)

CTENODACTYLIDAE Indet,; cited (as Sciuravidae) by Tong & Wang, 1980, V.P. (1)

6 Chugouyu = Chou (= a kind of triangular hoe) valley.
7 See footnote n° 11, p. 77.

Source : MNHN, Paris

PERISSODACTYLA

EOMOROPIDAE
— *Litolophus major* (Zdansky, 1930), Chow *et al.*, 1974, V.P. (4); cited by Tong & Wang & Wang, 1980, V.P. (1)
(= *Eomoropus? major* Zdansky, 1930)
(= *Grangeria? major* (Zdansky, 1930) Radinsky, 1964a)

LOPHIALETIDAE
— *Breviodon* n. sp.; cited by Tong & Wang, 1980, V.P. (1)

HYRACODONTIDAE
— *Forstercooperia* sp.; cited by Tong & Wang, 1980, V.P. (1)

ARTIODACTYLA

LEPTOMERYCIDAE
— *Archaeomeryx optatus* Matthew & Granger, 1925d; cited by Tong & Wang, 1980, V.P. (1)

Lat. 32° 25′ N
Long. 113° 30′ E
(Wucheng Town)

Fig. 2, n° 14

CHINA
HENAN PROVINCE
(Honan)
Wucheng Basin
Tongbai[8] Region

Wulidui Fm. **late Eocene**

The formations of the Wucheng Basin have been treated in some detail under the heading of the Lishigou Fm. The reader is referred to the middle Eocene section.

The Wulidui Fm. consists of thin-layered grayish green clay with intercalated dark brown shale; layers of salt occur. Formational thickness is 550 m.

Except for the presence of *Gigantamynodon* and *Sianodon*, in conjunction with its stratigraphical position, there is little evidence for correlating it with the Shara Murun. This view, however, seems probable and is retained here.

Fauna of the Wulidui Fm.

PERISSODACTYLA

HYRACODONTIDAE
— *Imequincisoria mazhuangensis* Wang, J.-w., 1976, V.P. (2)
(= *Juxia* n. spp. and Forstercooperiinae; cited by GAO, 1976, V.P. (1))
— *Imequincisoria micracis* Wang, J.-w., 1976, V.P. (1)
— *Imequincisoria*? sp.; cited by Wang, J.-w., 1976, V.P. (1) (foot bones)
— *Juxia borissiaki* (Belyayeva, 1959) Lucas *et al.*, 1981
(= *Eotrigonias borissiaki* Belyayeva, 1959)
(= *Forstercooperia borissiaki* (Belyayeva, 1959) Radinsky, 1967)
(= *Pappaceras* sp.; cited by Wang, J.-w., 1976, V.P. (1)

AMYNODONTIDAE
—*Sianodon sinensis* (Zdansky, 1930) Wang 1978, V.P. (1); cited by Chow & Xu, 1965, V.P. (2)
(=*Amynodon sinensis* Zdansky, 1930)
— *Gigantamynodon* sp.; cited by Wang, 1978, V.P. (1)
— cf. *Lushiamynodon* sp.; cited by GAO, 1976, V.P. (1)

8 Tongbai (= Tongbo) = place name.

Source : MNHN, Paris

Lat. 42° 30′ N
Long. 111° 45′ E, approx. Fig. 2, n° 2

CHINA
NEI MONGOL AUTONOMOUS REGION
(Inner Mongolia)

Shara Murun Formation **late Eocene**
Locality: Ula Usu

Fossil mammals were first discovered in the Shara Murun region (at Ula Usu[9]) in 1922 by the American Museum Expedition and large collections were made at the same locality in 1923 and 1925 and, later, in 1959, by the Sino-Soviet team; IVPP activity during the 1970's was concentrated in other areas, but some material was recovered from here.

The type section at Ula Usu (Baron Sog Mesa) consists of hard clay overlain by 70-100 m of soft, predominantly gray clays containing brown, red, and purple layers in their lower part. A rich and varied fauna of late Eocene age was found in the gray clays, which were called the Shara Murun Formation; the hard red clays at the base constitute the "Tukhum" (= Arshanto) Formation, although it is not clear whether all the red clays were placed in this formation or if some were included in the basal part of the Shara Murun Formation. Beds containing the Ulan Shireh or Irdin Manha fauna are absent here and nowhere in Inner Mongolia can the Shara Murun Formation be seen overlying the Irdin Manha; it therefore cannot be demonstrated whether the differences in their faunas are the result of different ecology or a difference in age. But in the Lushi Basin (Henan), a Shara Murun-like fauna does overlie an Irdin Manha-like fauna, thus suggesting the reality of the relationship. Also, the Irdin Manha and the Shara Murun faunas are quite distinct and certainly represent successive periods of time. In the northern and western parts of the Baron Sog Mesa, the Shara Murun Formation is overlain conformably by the Ulan Gochu Formation.

Again, we follow the opinion of the American Museum workers and consider the Shara Murun fauna to be late Eocene in age, younger than that of Irdin Manha.

Fauna of the Shara Murun Formation

LAGOMORPHA
- LEPORIDAE
  - — *Gobiolagus tolmachovi* Burke, 1941
  - — *Shamolagus medius* Burke, 1941
- OCHOTONIDAE
  - — *Desmatolagus* sp.; cited by Belyayeva *et al.*, 1974

RODENTIA
- CTENODACTYLIDAE[10]
  - — *Yuomys cavioides* Li, 1975, V.P. (1)

CREODONTA
- HYAENODONTIDAE
  - — cf. *Propterodon morrisi*; cited by Manning, pers. com. 1977
  - — "*Pterodon*" *hyaenoides* Matthew & Granger, 1925d; cited by Manning, pers. com., 1977

9 Ula Usu = good water (= mountain water, according to Chow & Rozhdestvensky, 1960).
10 See footnote n° 11, p. 77.

Source : MNHN, Paris

CONDYLARTHRA

MESONYCHIDAE
— "*Olsenia mira*" Matthew & Granger, 1925d (an astragalus; *nomen dubium*, *in* Szalay & Gould, 1966)

PERISSODACTYLA

BRONTOTHERIIDAE
— *Telmatherium*? sp.; cited by Manning, pers. com., 1977
— *Manteoceras*? sp.; cited by Manning, pers. com., 1977
— *Rhinotitan kaiseni* (Osborn, 1925) Granger & Gregory, 1943
(= *Dolichorhinus kaiseni* Osborn, 1925)
— *Rhinotitan mongoliensis*[11] (Osborn, 1923b) Granger & Gregory, 1943
(= *Protitanotherium mongoliense* Osborn, 1923b)
— *Rhinotitan andrewsi* (Osborn, 1925), Granger & Gregory, 1943
(= *Protitanotherium andrewsi* Osborn, 1925)
— *Pachytitan ajax* Granger & Gregory, 1943
— *Titanodectes minor* Granger & Gregory, 1943
— *Titanodectes ingens* Granger & Gregory, 1943
(*Protembolotherium efremovi* Tang *et al.*, 1974, V.P. (4), was cited here in error)

CHALICOTHERIIDAE
— *Schizotherium* sp.; cited by Belyayeva *et al.*, 1974

DEPERETELLIDAE
— *Teleolophus medius*?; cited by Manning, pers. com., 1977
— *Deperetella cristata* Matthew & Granger, 1925d

LOPHIALETIDAE
— *Lophialetes* sp.; cited by Radinsky, 1965 (stratigraphic position uncertain)

LOPHIALETIDAE?
— *Rhodopagus minimus* (Matthew & Granger, 1925d) Lucas & Schoch, 1981b
(= *Rhodopagus*? *minimus* (Matthew & Granger, 1925d) Radinsky, 1965)
(= *Caenolophus*? *minimus* Matthew & Granger, 1925d)

HYRACODONTIDAE
— *Triplopus*? *progressus* (Matthew & Granger, 1925d) Radinsky, 1967
(= *Caenolophus progressus* Matthew & Granger, 1925d)
— *Juxia borissiaki* (Belyayeva, 1957) Lucas *et al.*, 1981
(= *Forstercooperia sharamurenense* (Chow & Chiu, 1964); cited by Belyayeva *et al.*, 1974)
(= *Eotrigonias borissiaki* Belyayeva, 1957)
(= *Forstercooperia sharamurenense* (Chow & Chiu, 1964), Radinsky, 1967)
(= *Juxia sharamurenense* Chow & Chiu, 1964, V.P. (3))

AMYNODONTIDAE
— *Sharamynodon mongoliensis* (Osborn, 1936) Kretzoi, 1942
(= *Amynodon mongoliensis* Osborn, 1936)
— *Caenolophus obliquus* Matthew & Granger, 1925d
— *Caenolophus promissus* Matthew & Granger, 1925d
— *Sianodon ulausuensis* Xu, 1966, V.P. (2)
— *Sianodon* sp.; cited by Xu, 1966, V.P. (2)
— *Lushiamynodon sharamurenensis* Xu, 1966, V.P. (2)
— *Gigantamynodon promissus* Xu, 1966, V.P. (2)
— cf. *Cadurcodon* sp.; cited by Manning, pers. com., 1977

ARTIODACTYLA

ANTHRACOTHERIIDAE
— *Ulausuodon parvus* Hu, 1963, V.P. (4)
— cf. *Anthracokeryx* sp.; cited by Manning, pers. com., 1977

LEPTOMERYCIDAE
— *Archaeomeryx optatus* Matthew & Granger, 1925d

11 A monographic treatment of the osteology and phylogenetic relationships of this species was made recently by Wang, B.-y., 1982.

Source : MNHN, Paris

Lat. 35° 06′ N
Long. 111° 53′ E
(Old City of Yuanqu)

Fig. 2, n° 7

CHINA
SHANXI (and HENAN) PROVINCES
(Shansi, Honan)
Yuanqu Basin

Heti Fm. **late Eocene**

The late Eocene beds of Henan and Shanxi are among the most richly fossiliferous of the known early Tertiary mammal-bearing deposits in China. Vertebrate fossils have been found in many small continental early Tertiary basins of this region. They are the Lushi, Tantou, Lingbao,

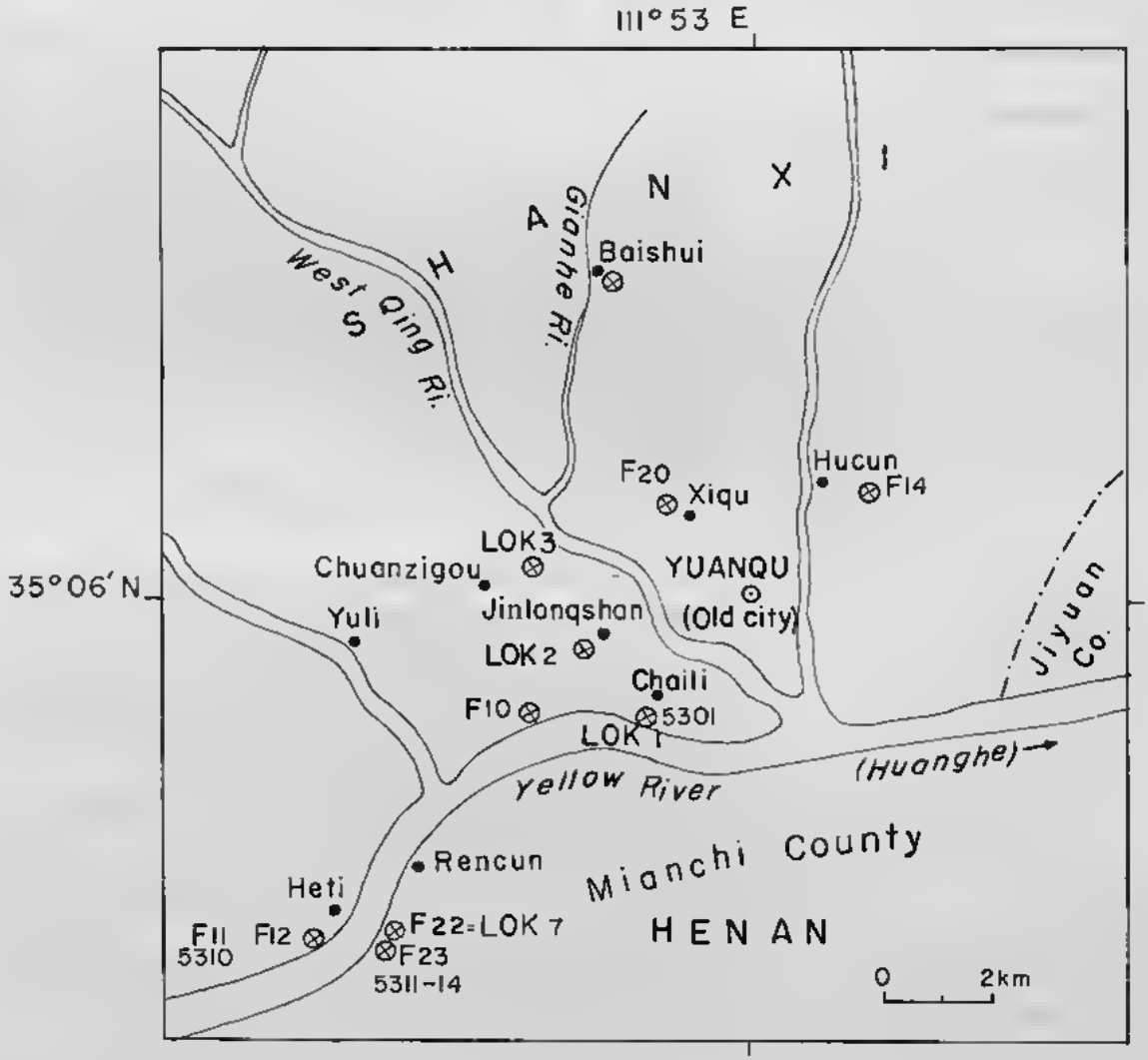


FIG. 123. — Fossil mammal localities of the Yuanqu-Mianchi Basin of Henan (Mianchi and Jiyuan Counties) and Shanxi (Yuanqu County). Lok. 1 of Zdansky, 1930 = River Section of Andersson, 1923 = IVPP locality 5301 of Chow, 1953. Modified from Chow *et al.*, 1973.

Source : MNHN, Paris

Xichuan basins in western Henan, and the Yuanqu[12] and Jiyuan Basins, which are mainly in Shanxi but also extend slightly into the northern part of Henan. Only the Lushi and Yuanqu Basins have yielded a large number of vertebrate fossils, although the others are perhaps potentially important.

The Heti[13] Formation occurs in the Yuanqu Basin of the lower middle Huanghe (Yellow River) and is located in the counties of Yuanqu (southern Shanxi) and Mianchi (Henan). The various localities known from the Yuanqu Basin have been described and discussed many times since the early thirties; a large collecting party from the IVPP worked here in 1953. At least 3 mammalian levels are known in the 1,000 m of strata that comprise the early Tertiary Yuanqu Series. The lower faunal zone contains the Heti fauna, represented at the locality of Rencun (= Jentsen, = Lok. 7 of Zdansky), on the southern bank of the Huanghe in Mianchi, about 1 km south of the village of Rencun[14]. This zone is contained in the Rencun Member of the Heti Formation. The second, or middle faunal zone (in the Chaili[15] Member) is found on the north bank of the Huanghe and includes localities known as the River Section (Andersson, 1923), Lok. 1, 2 and 3 (Zdansky, 1930) and F 10, 14 and 20 (Lee and Young, 1936-1937). All are within the upper part of the Heti Formation. The upper faunal zone is in the Baishuicun[16] Formation, which overlies the Heti Formation and which is characterized by a single species of *Brachyodus* (*B. hui*) that is probably of Oligocene age.

Most of the mammalian forms found in the upper part of the Heti Formation also occur in the lower zone and both are considered to comprise the Heti fauna. Although slightly different in age, both are thought to be of late Eocene age; in any case the fauna is too homogenous to be spilt at this time. It is noteworthy that it does not contain an Irdin Manha element.

The bottom of the Yuanqu Series is not visible in the Yuanqu Basin, but in a recently investigated small basin nearby, middle Eocene beds apparently underlie it; they have not yet been studied however.

Fauna of the Heti Fm. (upper part: Chaili Member)

INSECTIVORA Incertae sedis	— *Ictopidium lechei* Zdansky, 1930[17]
PRIMATES	
Family Indet.	— *Hoanghonius stehlini* Zdansky, 1930
RODENTIA	
Cricetidae	— "*Cricetodon*" *schaubi* Zdansky, 1930 (= *Eucricetodon schaubi* (Zdansky, 1930), *in* Hartenberger *et al.*, 1975) (= generically indeterminate, *in* Lindsay, 1977)
Dipodidae	— *Parasminthus* sp.; cited by Hugueney & Vianey-Liaud, 1980 (this genus was synonymized with *Plesiosminthus* by Stehlin & Schaub, 1951, and followed by Kowalsky, 1974; Engesser, 1979, considers both genera valid.)
Ctenodactylidae Indet.; cited by Vianey-Liaud, 1985	(= Ischyromyidae indet.; cited by Hartenberger *et al.*, 1975)
CARNIVORA	
Canidae[18]	— *Chailicyon crassidens* Chow, 1975, V.P. (3)

12 Yuanqu = Yuanchu.
13 Heti (= Holi) = river bank.
14 Rencun (= Jentsen): Ren (family name) village.
15 Chaili = within a walled village.
16 Baishuicun = white river village.
17 Attributed to the Erinaceidae by Butler, 1951, but placed in Insectivora *incertae sedis* by Novacek *et al.*, 1985.
18 Familial attribution doubted by D. E. Savage, pers. com., 1985.

Source : MNHN, Paris

CREODONTA
- HYAENODONTIDAE — *Hyaenodon yuanchuensis* Young, 1937

PERISSODACTYLA
- BRONTOTHERIIDAE — *Rhinotitan mongoliensis* (Osborn, 1923b) Granger & Gregory, 1943; cited by Chow *et al.*, 1973, V.P. (2)
  (= *Protitanotherium mongoliense* Osborn, 1923b)
- AMYNODONTIDAE — *Sharamynodon mongoliensis*? (Osborn, 1936) Kretzoi, 1942
  (= *Amynodon mongoliensis*? Osborn, 1936; cited by Chow *et al.*, 1973, V.P. (2))
- — *Sianodon sinensis* (Zdansky, 1930), Chow & Xu, 1965, V.P. (2)
  (= *Amynodon sinensis* Zdansky, 1930)
- — *Amynodon* sp.; cited by Chow *et al.*, 1973, V.P. (2)
  (= *Cadurcodon ardynensis* Osborn, 1923c; cited by Young, 1937)
  (= *Cadurcotherium ardynense* Osborn, 1923c)

ARTIODACTYLA
- ANTHRACOTHERIIDAE — *Anthracokeryx dawsoni* Wang, 1985, V.P. (1)
- — *Anthracokeryx sinensis* (Zdansky, 1930) Xu, 1962, V.P. (3)
  (= *Anthracotherium? sinensis* Zdansky, 1930)
- — *Anthracokeryx* cf. *sinensis* (Zdansky, 1930); cited by Chow *et al.*, 1973, V.P. (2)
- FAMILY Indet. — "*Hoanghonius stehlini*" (Zdansky, 1930); cited by Woo & Chow, 1957, fig. 2, V.P. (4)
  (= artiodactyl indet.; cited by Dashzeveg & McKenna, 1977)

Fauna of the Heti Fm. (lower part: Rencun Member)

PRIMATES
- FAMILY Indet. — *Hoanghonius stehlini* Zdansky, 1930; cited by Woo & Chow, 1957, V.P. (4)

TILLODONTIA
- TILLOTHERIIDAE — *Adapidium huanghoensis* Young, 1937
- — Tillodontia indet., sp. 1; cited by Chow, 1963, V.P. (2)

RODENTIA
- CTENODACTYLIDAE[19] — *Yuomys cavioides* Li, 1975, V.P. (1)

CREODONTA
- HYAENODONTIDAE — *Pterodon* cf. *dahkoensis* Chow, 1975; cited by Chow, 1975, V.P. (3)

CONDYLARTHRA
- MESONYCHIDAE — *Honanodon hebetis* Chow, 1965, V.P. (3)

PERISSODACTYLA
- EOMOROPIDAE — *Eomoropus quadridentatus* (Zdansky, 1930) Radinsky, 1964a
  (= *Eomoropus? quadridentatus* Zdansky, 1930)
  (= *Eomoropus? minimus* Zdansky, 1930, *in* Radinsky, 1964a; cited by Hu, 1959)
- — *Litolophus major* (Zdansky, 1930) Chow *et al.*, 1974, V.P. (4)
  (= *Eomoropus? major* Zdansky, 1930)
  (= *Grangeria? major* (Zdansky, 1930) Radinsky, 1964a)

19 See footnote n° 11, p. 77.

Source : MNHN, Paris

ISECTOLOPHIDAE? Indet.; cited by Zdansky, 1930

DEPERETELLIDAE
— *Deperetella depereti* (Zdansky, 1930) Radinsky, 1965
(= *Cristidentinus depereti* Zdansky, 1930)
— *Diplolophodon similis* Zdansky, 1930
(= *Deperetella similis* (Zdansky, 1930) Radinsky, 1965)
(*Diplolophodon* revalidated by Ding *et al.*, 1977, V.P. (1))

LOPHIALETIDAE?
— *Rhodopagus*? sp.; cited by Radinsky, 1965

HYRACODONTIDAE
— *Prohyracodon* cf. *meridionale* Chow & Xu, 1961, V.P. (4); cited by Chow *et al.*, 1973, V.P. (2)

AMYNODONTIDAE
— *Sianodon sinensis* (Zdansky, 1930) Chow *et al.*, 1965, V.P. (2)
(= *Amynodon sinensis* Zdansky, 1930)
— *Sianodon mienchiensis* Chow & Xu, 1965, V.P. (4)
— *Sharamynodon mongoliensis* (Osborn, 1936) Kretzoi, 1942
(= *Amynodon mongoliensis* Osborn, 1936)
— *Caenolophus* cf. *promissus* Matthew & Granger, 1925d; cited by Chow *et al.*, 1973, V.P. (2)
— *Amynodon*? sp.; cited by Zdansky, 1930

ARTIODACTYLA

ANTHRACOTHERIIDAE
— *Anthracothema minima* Xu, 1962, V.P. (3)
— *Anthracokeryx sinensis* (Zdansky, 1930) Xu, 1962, V.P. (3)
(= *Anthracotherium? sinensis* Zdansky, 1930)
— *Anthracosenex ambiguus* Zdansky, 1930

HELOHYIDAE
— *Indohyus? yuanchuensis* (Young, 1937) Coombs & Coombs, 1977
(= *Gobiohyus yuanchuensis* Young, 1937)

FAMILY Indet.
— "*Dichobune*" sp.; cited by Zdansky, 1930 (doubted by the authors)

Lat. 44° N, approx.
Long. 86° E, approx.

Fig. 2, n° 34

CHINA

XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)

Southern part of the Junggar Basin — **late Eocene**

"lower green" formation

Localities: South Anjihai and Usu

The locality of "South Anjihai" does not exist as a place name; its meaning was simply a site south of Anjihai[20], a town situated at the southern border of the Junggar[21] Basin. The locality from which a geologist collected (in about 1956) a specimen of *Bothriodon* occurs on the east bank of the Holgos[22] River, about 40 km south of Anjihai. It was found in the "lower green"[23] formation, for which no formal name has been proposed. This green shale deposit is

20 Anjihai (= Ansihai).
21 Junggar (= Dzhungaria).
22 Holgos (= Orgos).
23 "lower green" = luse.

Source : MNHN, Paris

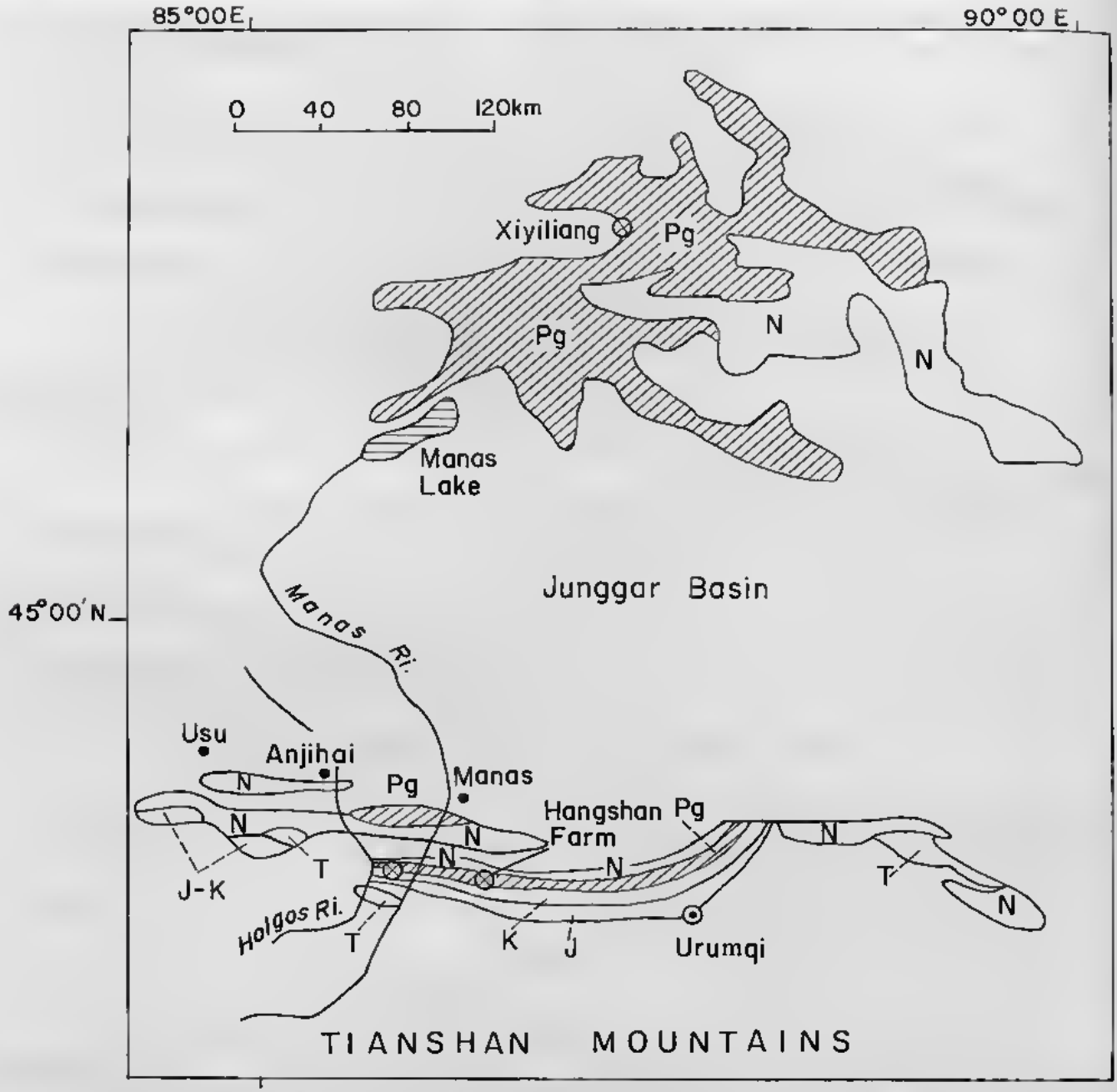


FIG. 124. — Outcrop map of the fossil mammal localities in the early Tertiary beds of the Junggar Basin, Xinjiang. J-K, Jurassic to Cretaceous; K, Cretaceous; N, Neogene; Pg, Paleogene; T, Triassic. Modified from a map provided by Zhai R.-j.

500-600 m thick and contained the specimen in its upper part. It crops out on the southern limb of the Manas syncline, on the northern slope of the Tianshan mountains. It is overlain by the Oligocene "brown" formation; beneath it lies the "red" formation, consisting of clays, sandy clays and sandstones; in the latter a single tapiroid molar was found, but it is inadequate for dating the formation.

At the time of its description it was thought that *Bothriodon* was only found in early Oligocene deposits, as it is in Europe and North America. It is still not conclusively demonstrated that the contrary is true, as the species from the "Naduo" Fm. (Eocene or Oligocene of Guangxi) attributed to *Bothriodon* is probably too primitive to be referable to that genus. The age of the "lower green" formation, and of its *Bothriodon*, is rather uncertain.

In 1975, Mr. Wu Shaozu of the Xinjiang

Source : MNHN, Paris

Geological Bureau in Urumqi sent two fragmentary vertebrate fossils to the IVPP for identification. They were found in the Usu[24] area of the southern Junggar Basin, Xinjiang. The details of the locality and the formation from which the material came were not exactly known. Judging from the stage of evolution of the fossils and the greenish sandy marl matrix from which they were recovered, it is believed that they came from the "lower green formation" of this district.

Of the two specimens (described by Zhou *et al.*, 1982), one is a fragmentary bird bone and the other is referable to an anthracothere. The latter is very similar to the *Probrachyodus* of Lunan, Yunnan, and could suggest a late Eocene age for the rocks containing it.

Fauna of the "lower green" formation

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Bothriodon* sp.; cited by Chow, 1960, V.P. (2)
— cf. *Probrachyodus* sp.; cited by Chow *et al.*, 1982

Lat. 0° 22′ N, approx.
Long. 110° 38′ E, approx.

INDONESIA

KALIMANTAN

(Indonesian Borneo)

Sanggau District

Melawi Formation **late Eocene**

The Melawi Group of western "Borneo" (Kalimantan) has been regarded as early Tertiary in age since 1858 on the basis of its marine mollusks. A crocodile tooth and turtle plates were cited by Zeylmans van Emmichoven (1939), but the interest of these beds for mammalian paleontologists stems from the description of one and a half teeth by Stromer (1931). Little has been said concerning the exact locality of the discovery and of the beds in which they were found, but it is known that the rock containing the teeth is a fine-grained, brownish red sandstone and that it is situated in the Sanggau District on a tributary of the Sei Sekajam.

The Melawi Formation occupies an intracratonic basin, comprising a large area west and south of the Madi Highland in central Kalimantan (see Bemmelen, 1949; Marks, 1957). The area is divided into two parts, the smaller one being situated north of Sanggau village (100 km wide by 50 km in a north-south direction), and the other east of Sintang village (200 km wide and 60 km north-south). A great variety of clastic sediments characterize the formation; its main components are clayshales and sandstones. Two members have been distinguished: the lower member, or Melawi Formation proper, and an overlying Lebang Claystone Member. Marls, calcareous sandstone, sandy limestone and intercalations of lignite and plant remains are also present in the Melawi Member. Red colored clayshales, sandy marls and arkose sandstone are characteristic of the upper member.

The total thickness of the Melawi Group may attain 9,700 m. It overlies unconformably the folded Mesozoic and is overlain conformably by the Plateau Sandstone Formation, which is also considered a lateral equivalent of the upper part of the Melawi Group, and unconformably by Recent river deposits.

24 Usu (= Wusu) = water.

Source : MNHN, Paris

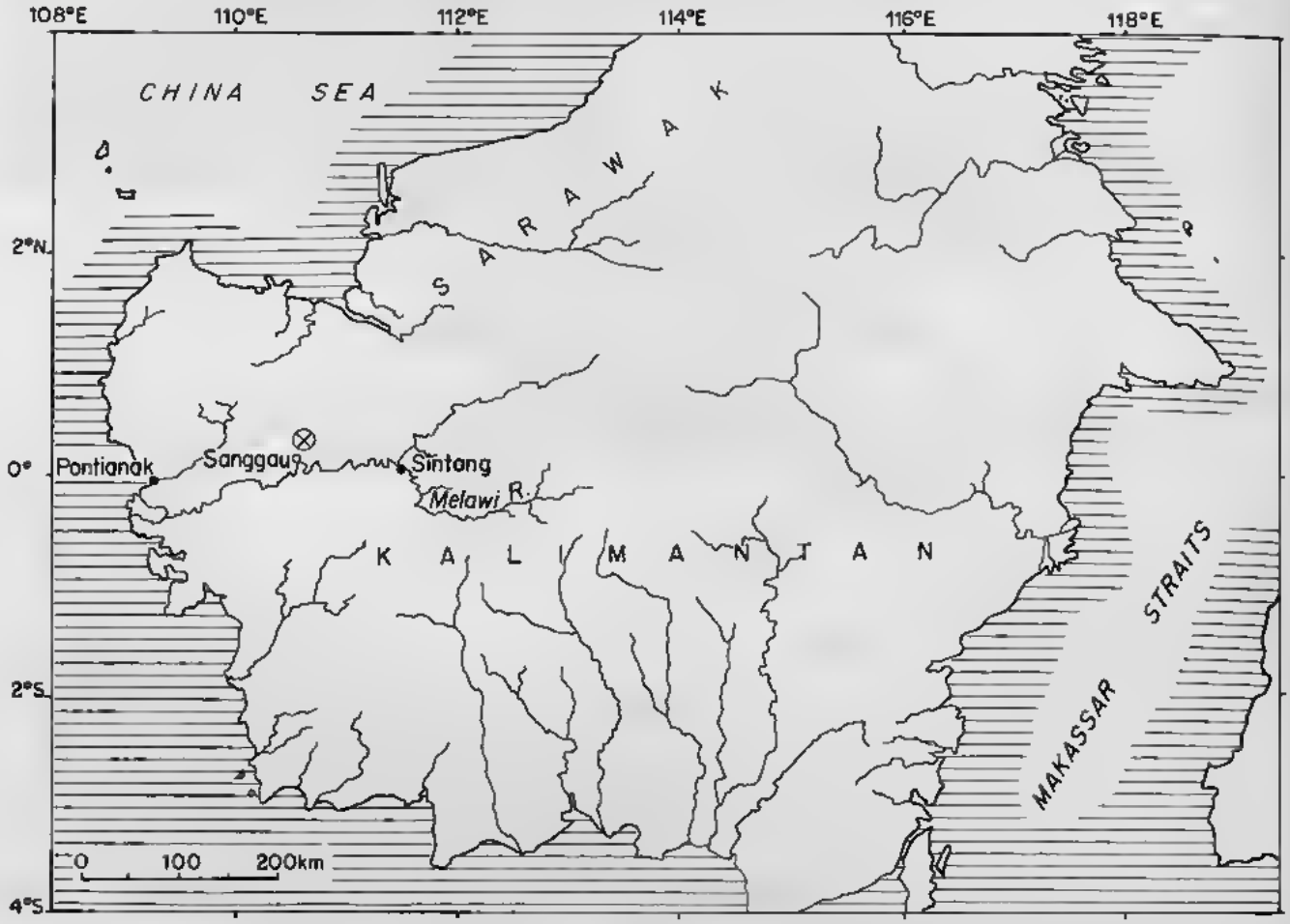


FIG. 125. — Sketch map of Kalimantan, Indonesia, showing the position of the area that reputedly produced fossil mammals. Modified from the Times Atlas, 1974.

It is presumed that the mammalian specimens came from the lower member, as, it is indicated, did the reptile bones.

A precise age appears to depend upon the identification of the mammal teeth; more are obviously necessary. The smaller of the two specimens is figured as X 1, but the dimensions in the text indicate that the illustration is really X 2. For the larger and more fragmentary specimen, it is impossible to know if it, too, is enlarged or if it is X 1 as given in the legend. Both of the teeth could belong to anthracotheres; the tooth identified as *Choeromorus* is probably not of that genus, as noted by Sudre (1978, p. 166) But if both are anthracotheres, neither is referable to known genera, according to Dineur (pers. com., 1981). The absence of a mesostyle indicates that both are primitive forms, which would tend to support a late Eocene age for the Melawi Formation.

Thenius (1959) mentions sirenian remains in Eocene beds not belonging to the Melawi Group, but no precise information is given.

Fauna of the Melawi Formation

ARTIODACTYLA

ANTHRACOTHERIIDAE Indet.; two forms; cited by Stromer, 1931.

Source : MNHN, Paris

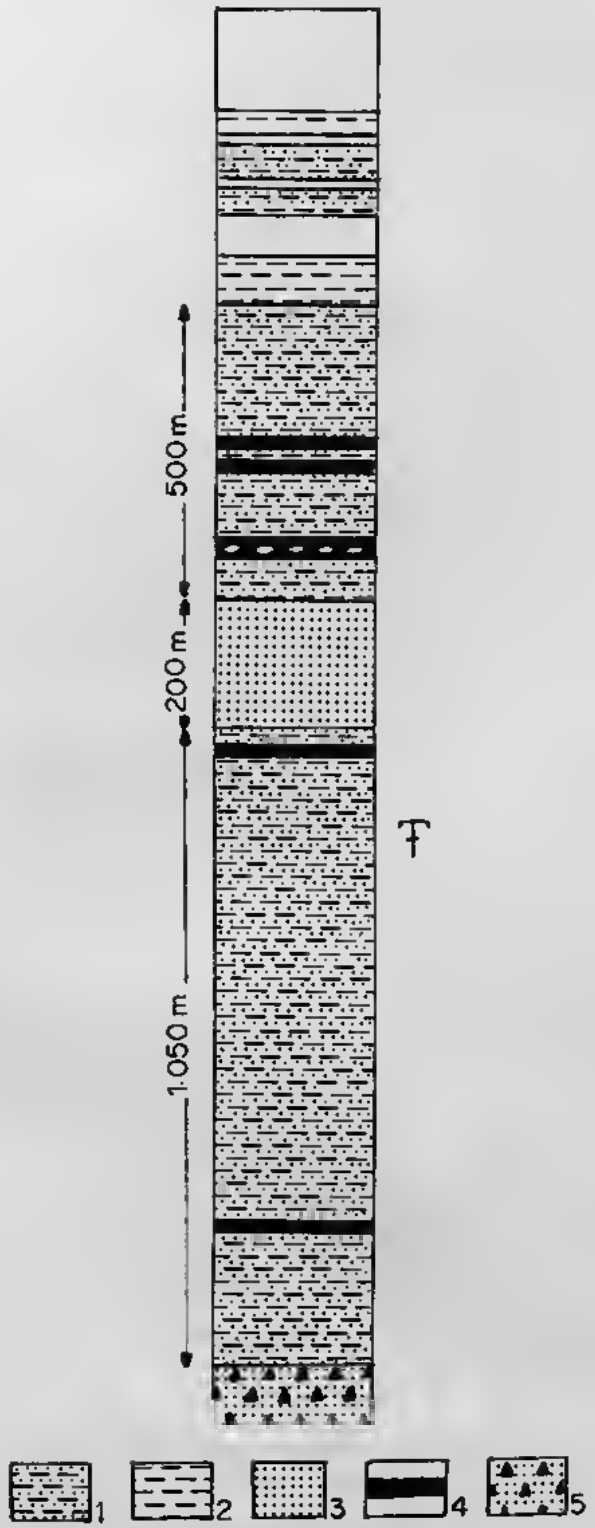


FIG. 126. — Section through the Melawi sediments in Kalimantan, Indonesia. The fossiliferous level indicated marks the discovery of a crocodile tooth. The level that yielded the mammalian specimens is not known. 1. sandy silt or shale; 2. silt; 3. sandstone; 4. coal; 5. basal arkose. Modified from Zeylmans van Emmichoven, 1955.

Source : MNHN, Paris

Lat. 9° 7′ S, approx.
Long. 125° 1′ E, approx.

INDONESIA
TIMOR
Atambua District

unnamed formation **late Eocene**
Locality: Lahurus

The discovery of the single Paleogene mammalian specimen known from Timor took place in January, 1966, by a small group of teachers (including Marcus and Lucianus Mau) traveling on foot from Lahurus to Desa Takrawat (?). The locality is situated on the left bank of the small Mota Baur stream, in a valley about 2-3 km west of Lahurus. The specimen was found as they were going up the west bank, about 50 meters from the stream. Mr. Domi Koten (University of Kupang), with Friar Vianney, visited Lahurus in July of the same year and received the fossil from Marcus Mau. They, in turn, transmitted it to Dr. Th. Verhoeven who returned to Europe with it in February, 1967. After being studied and described by G. H. R. von Kœnigswald, the specimen

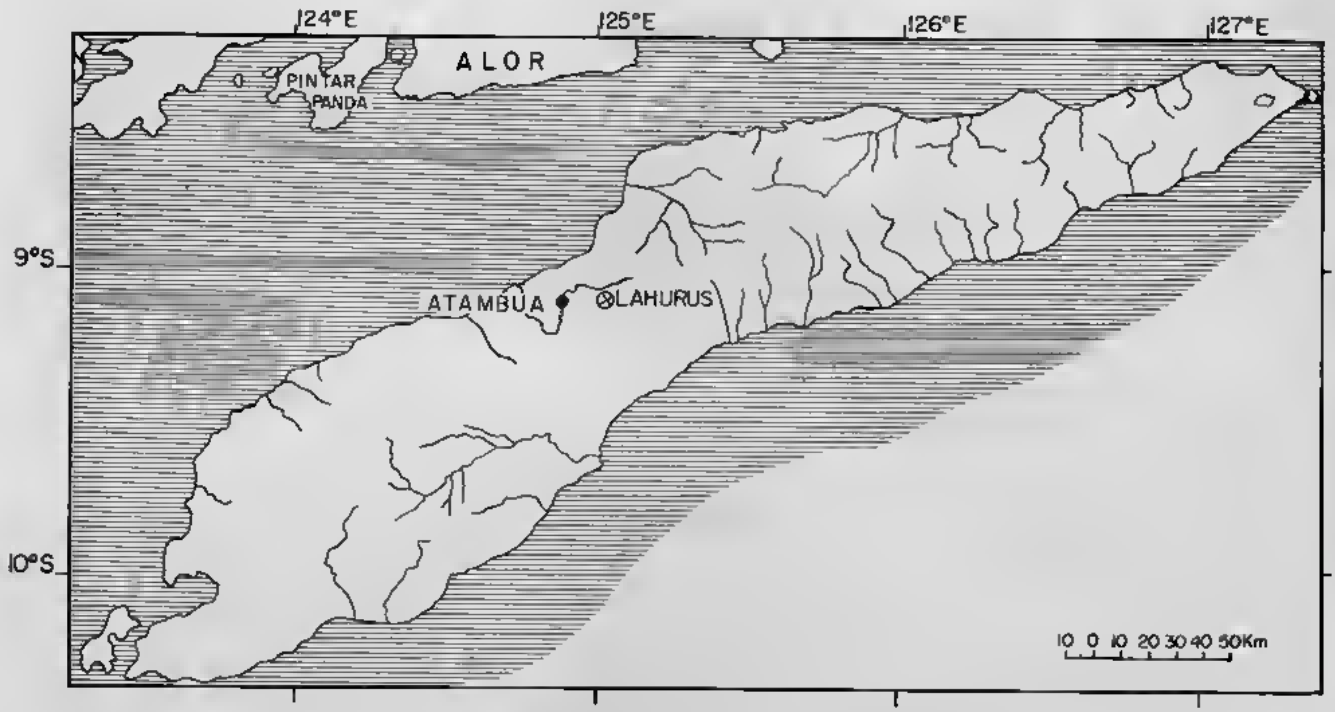


FIG. 127. — The island of Timor, Indonesia, showing the position of the fossil locality near Lahurus. Modified from maps provided by P. Y. Sondaar and the Indonesian Embassy (Paris).

was taken back to Indonesia and presented to the Service of Archaeology, Jakarta, in the care of Dr. Soejono.

In 1980 Prof. Santana, P. Sondaar (Utrecht) and B. Engesser (Basel), during a diversified paleontological expedition to Indonesia, investigated the area around Lahurus with the collector of the specimen. No further mammalian remains were discovered, however, during the four days spent there.

The sediments at the locality are red-brown in color and contain shells. Nummulites occur in

Source : MNHN, Paris

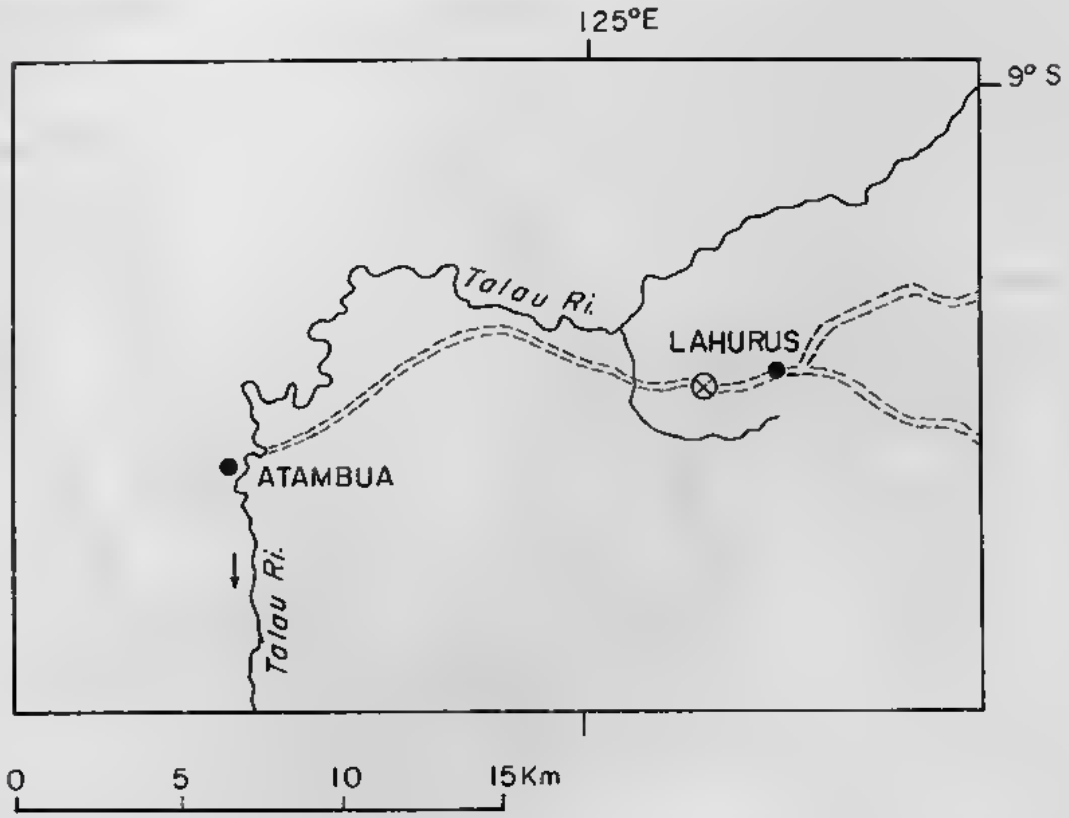


FIG. 128. — Detailed sketch of the region around Lahurus, Timor, Indonesia, showing the position of the fossil locality. The small stream Mota Baur, on whose banks the anthracothere was found, is not shown on the map, but presumably it flows northward toward the Talau River. From a drawing provided by Th. Verhoeven.

the region, probably below the level of the fossil mammal find (a fault runs through the area and the whole section is disturbed).

The nummulites have not been identified but accompanying nannoplancton suggests an Eocene age. Refinement to late Eocene is based solely on the stage of evolution of the anthracothere.

Fauna of Lahurus

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Anthracothema verhoeveni* von Kœnigswald, 1967

Source : MNHN, Paris

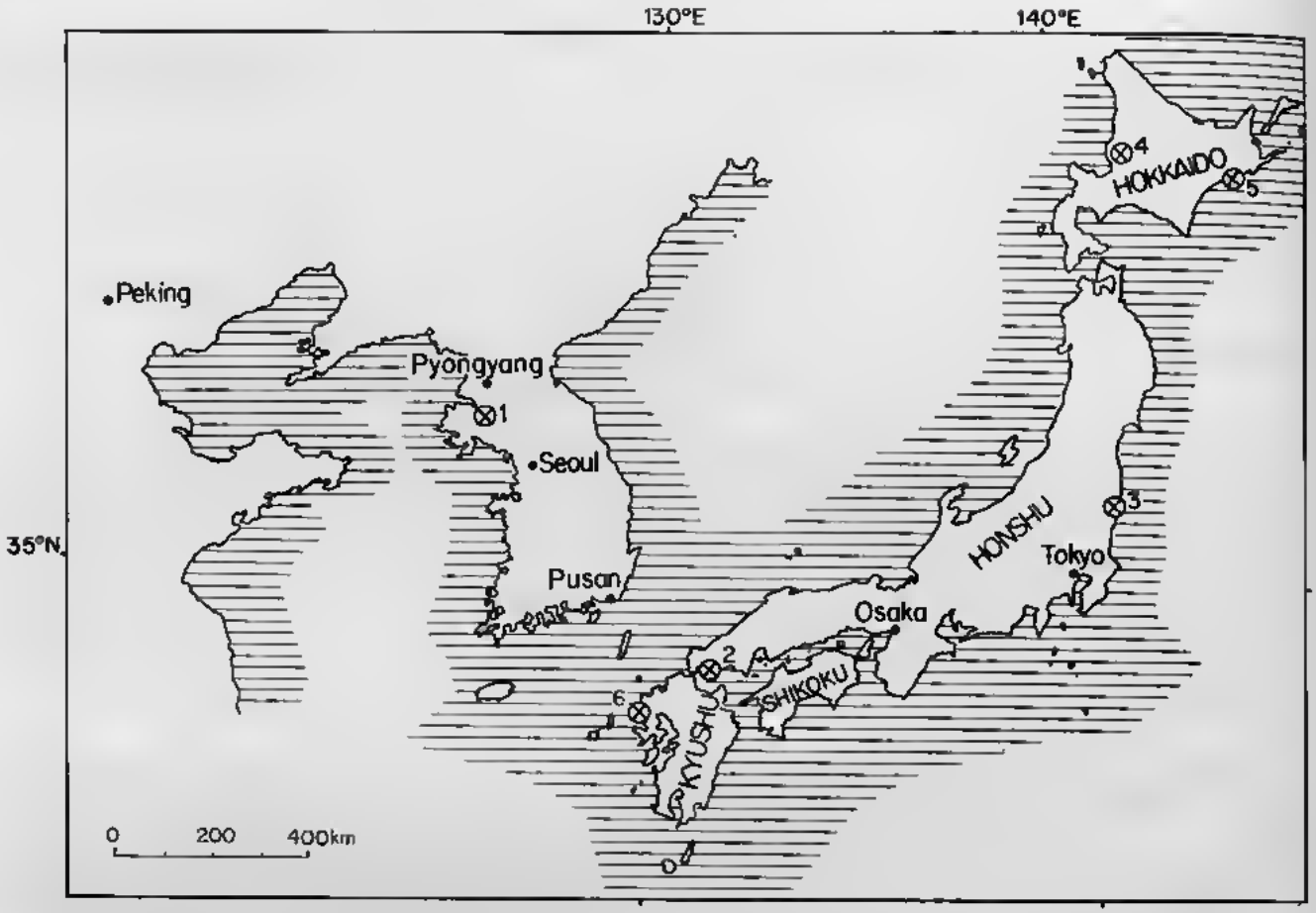


FIG. 129. — General map of Japan and Korea showing the geographic position of the following localities: **1**. Hôsan coal field, North Korea; **2**. Ube coal field, Honshu Island; **3**. Joban coal field, Honshu Island; **4**. Numata-Mura, Uryu coal field, Hokkaido Island; **5**. Kushiro coal field, Hokkaido Island; **6**. Sasebo, Ikena Coal Mine, Kyushu Island. Modified from a map provided by Y. Tomida.

Lat. 43° 54′ N approx.
Long. 141° 55′ E approx.

Fig. 129, n° 4

JAPAN

HOKKAIDO

Hokkaido Prefecture

Gonosawa Formation **late Eocene**

Localities: Numata-mura, Uryû coal field

A fossil mammal specimen was discovered by T. Yamamoto in the Gonosawa[25] Formation in 1947, at a point about 50 m northeast of the confluence of the small stream Takasago-zawa[26] with the River Horonitachibets[27], Numata-mura[28], Uryû-gun[29], west of Asahikawa. The Taka-

25 Gonosawa = the fifth stream (a branch of a river).
26 Takasogo = geographic name of unknown meaning; zawa = stream.
27 Horonitachibets = Ainu language.
28 Numata = geographic name of unknown meaning; mura = village. At present it is referred to as Numata-cho, or Numata town.
29 Uryû-gun; gun is a form of local government that is no longer used in Japan.

Source : MNHN, Paris

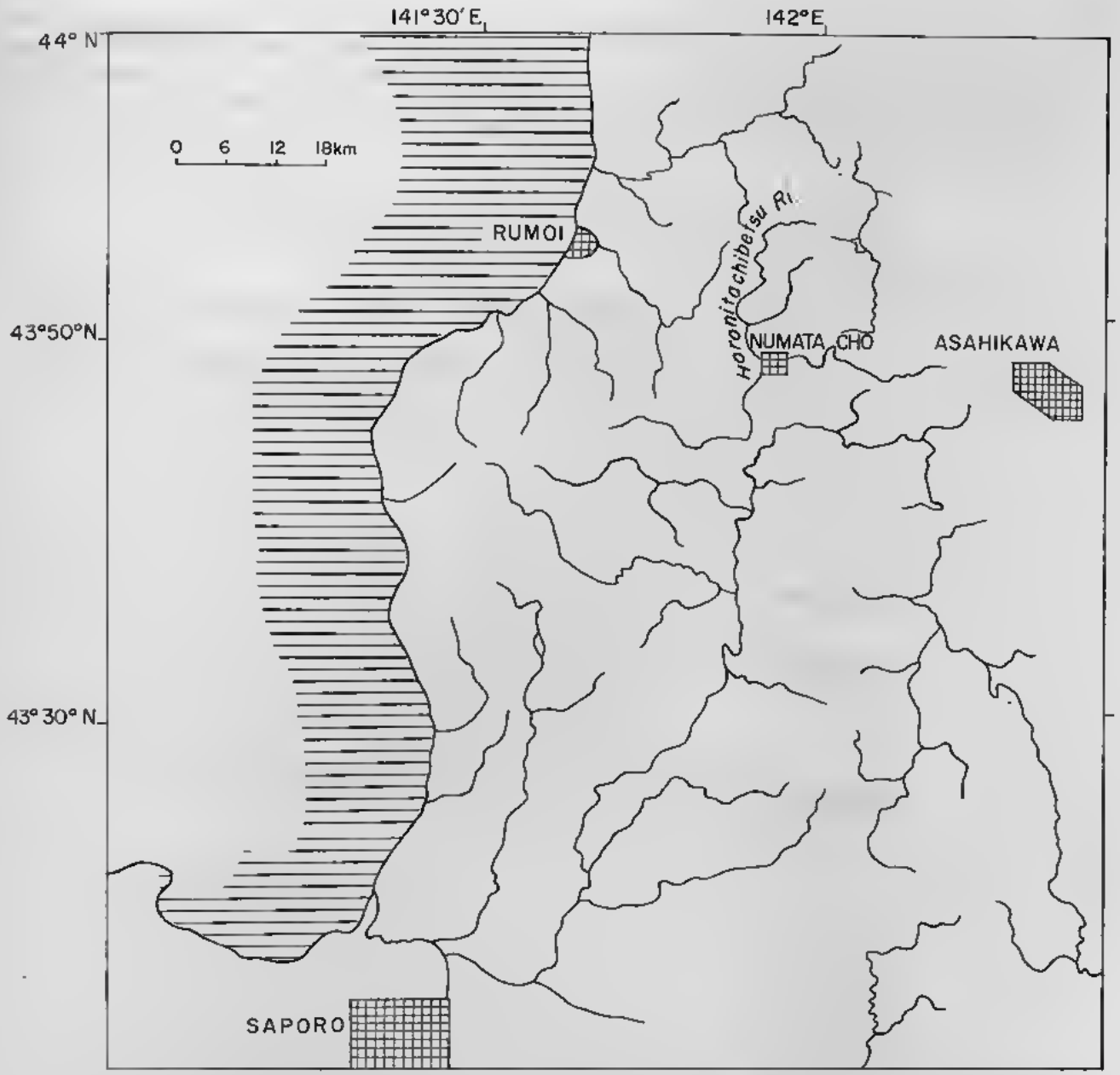


FIG. 130. — Map showing the position of the Horonitachibetsu River, on which the fossil mammal locality was cited at the Uryû coal field, near Numata-cho, Hokkaido, Japan. Modified from a map provided by Y. Tomida.

sago-zawa tributary is presently unknown and Numata-mura has grown to Numata-cho status. The exact situation of the fossil locality is not known.

The Gonosawa Formation (or perhaps better considered a member) constitutes the lower part of the Tachibets Formation, according to Saito, 1972, and consists principally of sandstone. It is overlain by the Numata Formation and underlain by the Uryû coal-bearing formation, both of uncertain age. Asano (1963) states that the *Amynodon* specimen was found in the Numata Formation, which is in apparent contradiction with most accounts, beginning with that of Takai (1950) who announced the discovery.

The Paleogene (the coal-bearing) formations in the Japanese Islands are characterized by deltaic deposits. They consist of marine, brackish and freshwater sediments and have yielded very few terrestrial mammal remains; the occur-

Source : MNHN, Paris

rence of planktonic Foraminifera is also limited, which renders difficult their correlation with the marine sequence.

The age of the Gonosawa Formation is presumed to be late Eocene in large part because of the specimen of *Amynodon* it contained. The early Oligocene Shimokine Fm., in this case well dated by Foraminifera, overlies unconformably the Uryû Group, of which the Gonosawa Formation is a part.

Fauna of the Gonosawa Fm. at the Uryû coal field

PERISSODACTYLA

AMYNODONTIDAE — *Amynodon watanabei* (Tokunaga, 1926) Takai, 1948; cited by Takai, 1950
(= *Aceratherium*? *watanabei* Tokunaga, 1926)
(= *Rhinoceros watanabei* Tokunaga, 1929)

Lat. 34° N approx.
Long. 131° 5′ E approx.

Fig. 129, n° 2

JAPAN
HONSHU
Yamaguchi Prefecture

Ube Formation **late Eocene**

Locality: Higashi-Misom Coal Mine (*fide* Chitani, 1925)
Okinoyama Colliery (*fide* Takai, 1950)

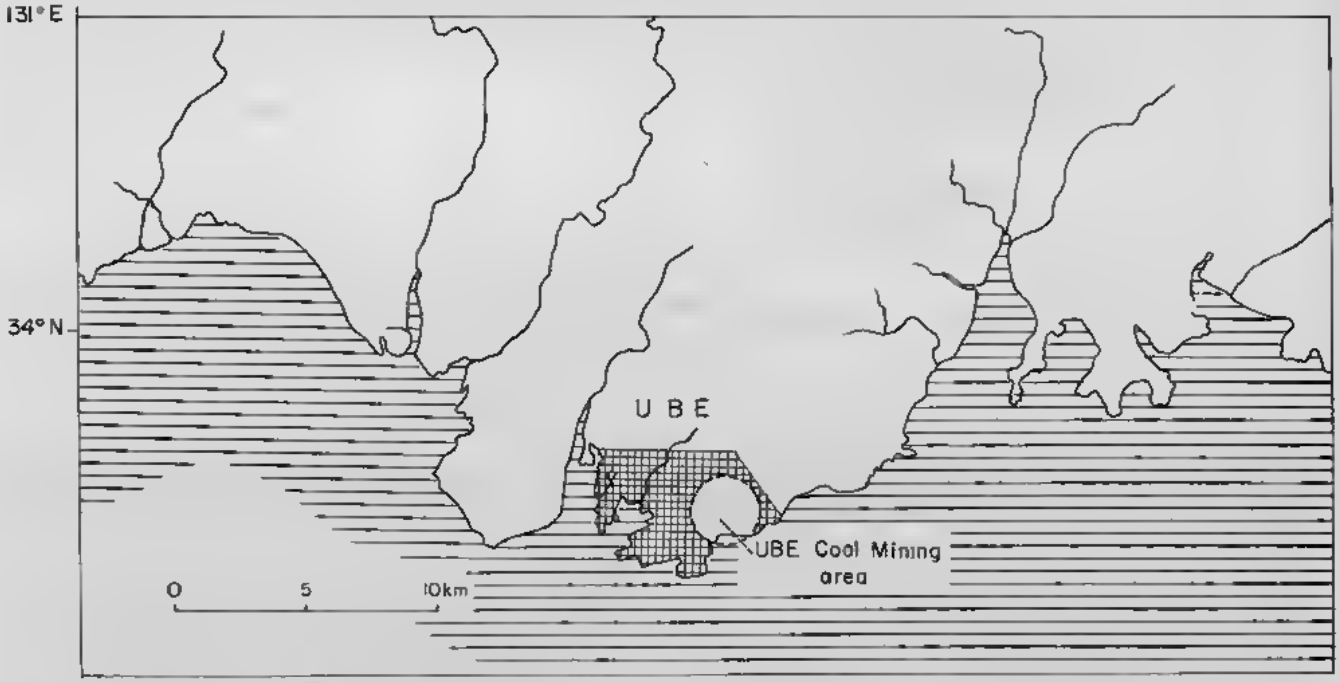


FIG. 131. — Map showing the position of the Ube coal mining area, Honshu, Japan; the exact situation of the fossil mammal locality is unknown. Modified from a map provided by Y. Tomida.

Source : MNHN, Paris

The Ube[30] coal field is situated at the western extremity of Honshu. Its geologic age was for many years thought to be Miocene, but by 1944 paleontological evidence of several sorts (paleobotanical, invertebrate) showed that it was referable to the late Eocene.

Five workable coal seams are known in the coal field and are called (in descending order):

— Hitoe[31] (*fide* Takai, 1944) (= Hitoishi, *fide* Takai, 1950);
— Hutae[32];
— Oha[33];
— Itudan[34] (*fide* Takai, 1944) (= Itsudan, *fide* Tokunaga, 1926 and Takai, 1950);
— Sanzyaku[35] (*fide* Takai, 1944) (= Hakama, *fide* Yabe, 1944; = Godan, *fide* Chitani, 1925).

Fossil mammals have been found in the uppermost main coal seam (the Hitoe) and in a sandy shale bed just above it; other specimens occurred in the Itudan coal seam (Takai, 1944, for example, although Tokunaga (1926) says both rami of a lower jaw came from 18 m below the Itsudan coal seam). Turtles from the Oha seam were described by Chitani (1925). The thickness of the coal formation being worked was about 150 m. The coal seams vary in thickness and at several levels there are intercalations of marine sediments.

The so-called Kûtûgawa conglomerate might underlie the coal formation (according to Tokunaga, *in* Yabe, 1944), or might be a lateral equivalent, as in the opinion of Yabe (1944). Saito (1972) cites the Higashimisome Formation as underlying the mammal-bearing upper beds; the latter form the surface of the Tertiary outcrop in the area.

The identification of fossils in the Ube Formation similar to those described from Hôsan weighed heavily in its age determination and correlation. For an analysis of the Hôsan fauna the reader is referred to that section.

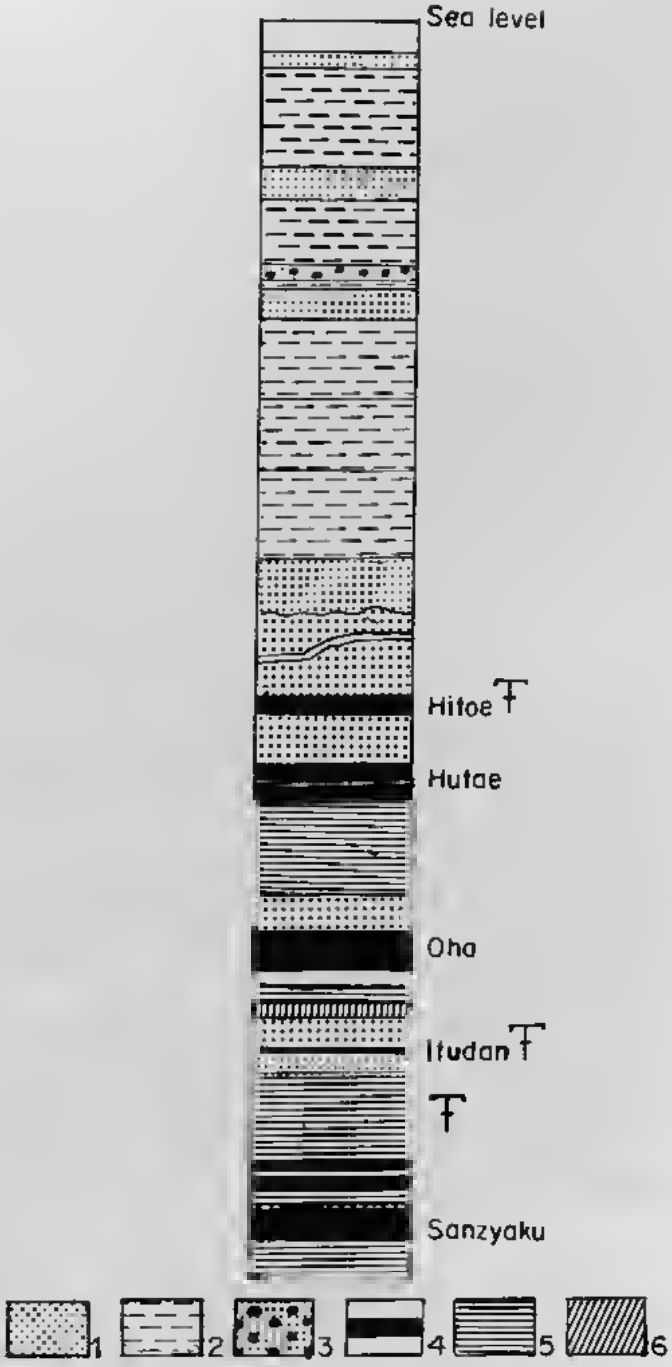


FIG. 132. — Section of the Ube Fm. at Ube, Japan. Thicknesses of both the coal seams and the interbedded deposits vary considerably. About 100 m of sediment is depicted here (not to scale). 1. sand; 2. clay; 3. gravel; 4. coal; 5. shale; 6. coal and shale. Modified from Chitani, 1925

30 Ube = geographical name of unknown meaning.
31 Hitoe = single; name applied to coal beds, as are the following.
32 Hutae = double.
33 Oha = unknown meaning.
34 Itudan = fifth stair.
35 Sanzyaku = three shaku; a shaku is about 30 cm; refers to the thickness of a coal seam.

Source : MNHN, Paris

Fauna of the Ube coal field

PERISSODACTYLA

HELALETIDAE — *Colodon? grangeri* (Tokunaga, 1933) Radinsky, 1965
(= *Desmatotherium grangeri* Tokunaga, 1933)

AMYNODONTIDAE — *Amynodon watanabei* (Tokunaga, 1926) Takai, 1948
(= *Aceratherium? watanabei* Tokunaga, 1926)
(= *Rhinoceros watanabei* Tokunaga, 1929)

Lat. 43° 36′ N
Long. 111° 30′ E

Fig. 1, n° 30

MONGOLIA

DORNOGOBI PROVINCE

unnamed svita **late Eocene?**

Locality: Alag-Tsav

The locality of Alag-Tsav[36] was discovered by Dashzeveg in 1982. It is situated 30 km south of Ulan-Badrakha.

Mammalian fossils occur in the middle part of a 25 m thick series of red clay and sand and light gray sandstone overlying levels of calcareous concretions. The fossiliferous bed is an argillaceous sandstone.

Correlation of the Alag-Tsav site is still precarious as few taxa are known. *Hyaenodon* and *Archaeomeryx* occur in both the Irdin Manha and Shara Murun faunal groups, but the species *Archaeomeryx optatus* is typically from the Shara Murun.

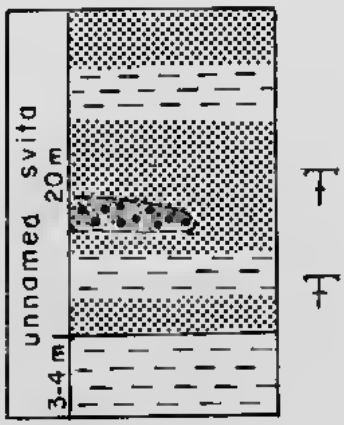


FIG. 133. — Stratigraphic section at the fossil locality of Alag-Tsav, Mongolia. The lower part is red clay and the upper, white beds. The latter forms the surface of the outcrop. Data from Dashzeveg, pers. com. 1985.

Fauna of the unnamed svita at Alag-Tsav

CREODONTA

HYAENODONTIDAE — *Hyaenodon* sp.; cited by Dashzeveg, pers. com., 1985

PERISSODACTYLA

HYRACODONTIDAE? Indet.; cited by Dashzeveg, pers. com., 1985
AMYNODONTIDAE Indet.; cited by Dashzeveg, pers. com., 1985

ARTIODACTYLA

LEPTOMERYCIDAE — *Archaeomeryx optatus* Matthew & Granger, 1925d; cited by Dashzeveg, pers. com., 1985

36 Alag-Tsav = variegated (in color) cliff.

Source : MNHN, Paris

Lat. 38° 29′ N, approx.
Long. 125° 49′ E, approx.

Fig. 129, n° 1

NORTH KOREA

Kokaido Province

Hôsan Formation **late Eocene?**

Locality: Hôsan coal field

Mammals from the Hôsan[37] coal field, in the central part of Kôkai dô[38], northwest Korea[39], were first reported by Nakamura (1926). The beds at that time were considered of Miocene age. Later, Tokunaga (1926) wrote briefly on a "rhinoceros" from the site, still thought to be Miocene, but in 1933, with additional fossil material, he revised his opinion of its age and proposed that it was late Eocene. Takai (1939a) reviewed the mammalian specimens that had

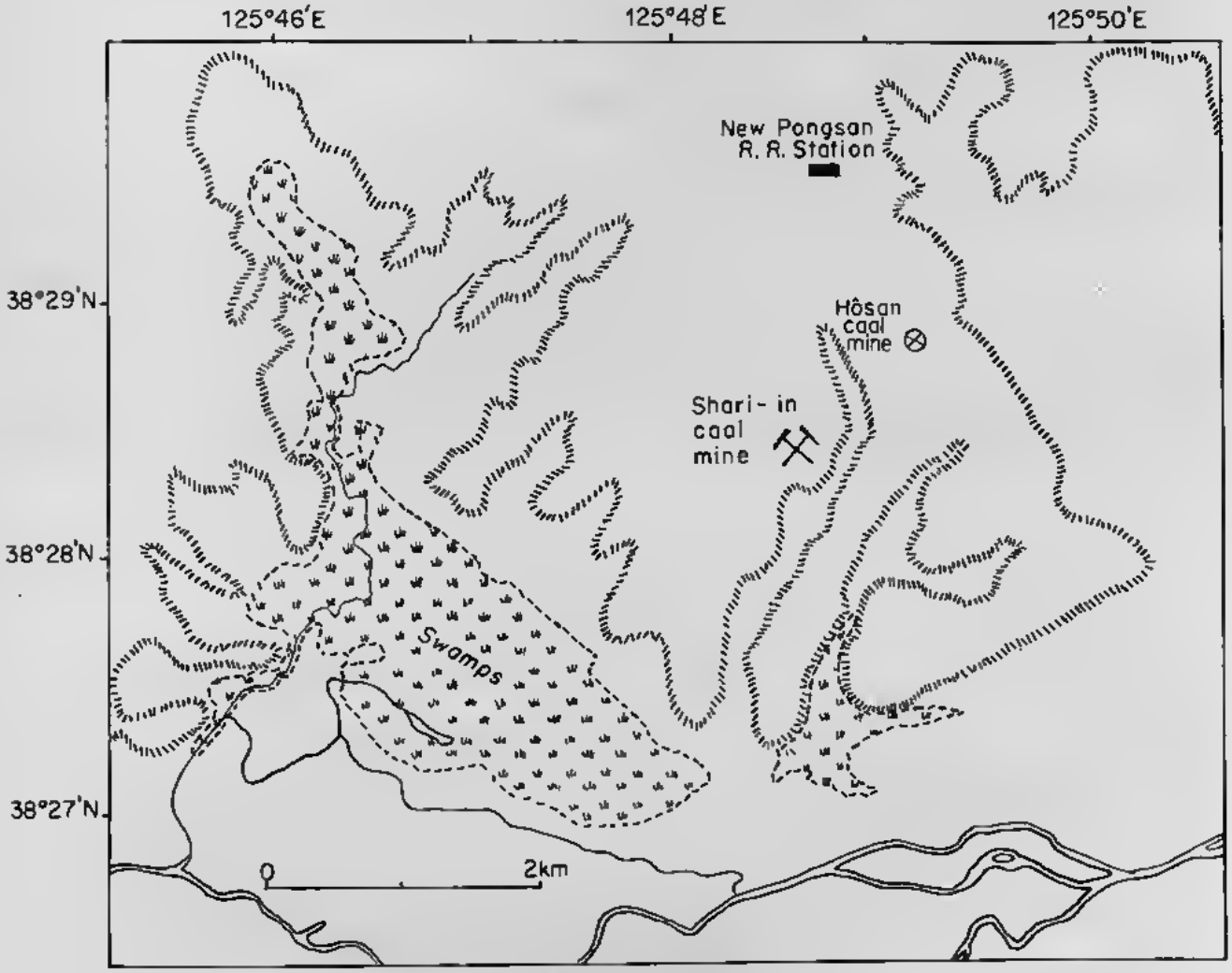


Fig. 134. — Map of the area around the Hôsan coal mine, North Korea. The town of Pongsan is situated off the map to the north about 1.5 km at the 125° 50′ meridian. Modified from a map provided by G. V. Shkurkin.

37 Hôsan = Hôzan = Pongsan.
38 Kôkai dô (= Kokaido) = Yellow Sea Province; this province was divided in the 1950's into north and south. Hôsan is in the North Yellow Sea Province.
39 Korea = Tyôsen = Chosen.

Source : MNHN, Paris

been slowly accumulating through the occasional efforts of non-paleontologists, and concurred as to the late Eocene age of the assemblage.

The Tertiary coal-bearing beds are lacustrine in origin and are composed of bluish gray shale, gray silty shale, siltstone, coaly shale and coal seams; in the central part of the basin there is a 50 m thick basal conglomerate. About a dozen coal seams are known that range in thickness from a few to several tens of centimeters. The coal field is elongate in a NE-SW direction. The northeast, northwest and southwest sides are bounded by normal faults. Although the strikes and dips of the beds are not constant, the geologic structure approximates an anticline. The Hôsan Formation is deposited on Precambrian limestone and is generally covered by Quaternary gravels.

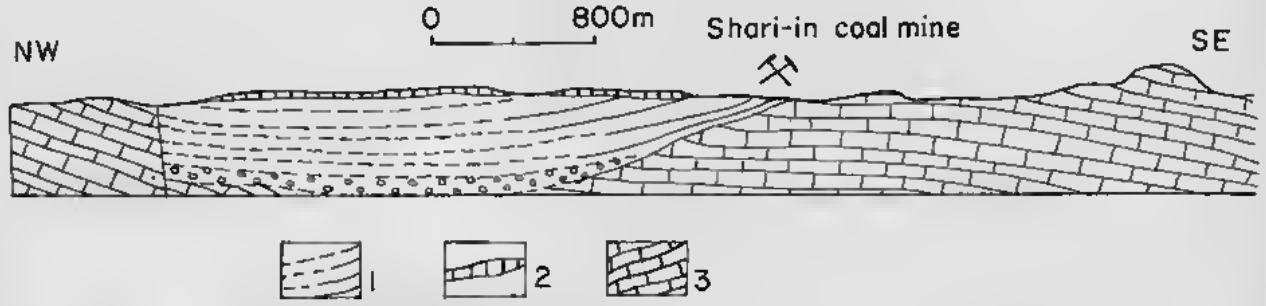


FIG. 135. — Cross section through the Hôsan coal field, North Korea. 1. The Hôsan Fm.; 2. Quaternary gravels which cover most of the Hôsan Fm.; 3. Precambrian limestone. Modified from Matsushita, Onomaya & Maejima, 1935.

The age of the Hôsan fossil beds was determined to be late Eocene on the basis of the resemblance between its fauna and that of the Irdin Manha Formation. We now believe the Irdin Manha Formation to represent the middle Eocene. In analyzing the Hôsan fauna, it can be seen that while *Protitan*? *koreanicum* and *Caenolophus makii* appear to be similar to elements of the Irdin Manha assemblage, the species of *Colodon* and *Colodon*? suggest a late Eocene or even early Oligocene age. As the Hôsan fauna is inadequately known by the described material, we will provisionally use the designation of late Eocene.

Fauna of the Hôsan Formation

CONDYLARTHRA

MESONYCHIDAE
— "*Harpagolestes*"? *koreanicus* (Shikama, 1943) Szalay & Gould, 1966
(= *Harpagolestes koreanicus* Shikama, 1943)

PERISSODACTYLA

BRONTOTHERIIDAE
— *Protitan*? *koreanicum* (Takai, 1939a)
(= *Protitanotherium koreanicum* Takai, 1939a)
(*Protitanotherium grangeri* (considered closest to *koreanicum* by Takai) was placed in *Protitan* by Granger & Gregory, 1943; it is questioned by the authors, who have not been able to verify the generic designation of *koreanicum*)

HELALETIDAE
— *Colodon hodosimai* Takai, 1939a
— *Colodon*? *grangeri* (Tokunaga, 1933) Radinsky, 1965
(= *Desmatotherium grangeri* Tokunaga, 1933)
(= *Cristidentinus* sp.; cited by Takai, 1944)

HYRACODONTIDAE
— *Caenolophus*? *makii* (Tokunaga, 1926) Takai, 1939a; generic designation questioned by the authors
(= *Aceratherium*? *makii* Tokunaga, 1926)

Source : MNHN, Paris

(= *Rhinoceros makii* Tokunaga, 1929)
(Takai considered *Caenolophus makii* as being closest to *C. proficiens* (referred to *Triplopus? in* Radinsky, 1967))

RHINOCEROTOIDEA
FAMILY Indet. — "*Lophialetes*" *tokunaga* (Takai, 1939a) Radinsky, 1965
(= *Lophialetes tokunaga* Takai, 1939a)

U.S.S.R.
KAZAKHSTAN S.S.R.
Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Kyzylkain Svita **late Eocene**

Locality: (Areal Site V, Aksyir River (Zheltye Pyatna)

Kyzylkain[40] mammals were collected in the 1960's and 70's by Chkhikvadze and Shevyreva on the right bank of the Aksyir River, especially on the north flank of the first Aksyir anticline. The svita is about 20 m thick, has a 20-25° northward dip, and is situated between the Aksyir and the Sargamys Svitas. The Zheltye Pyatna[41] locality is situated in the top half of the svita, near the southern base of the first northern cuesta (with a height of 40-60 m).

Analysis of the flora, in particular of the pollen, indicates a late Eocene age for these beds. The flora of the Kyzylkain Svita, for example, has been correlated with that of the Chegan Svita in the Turgay area.

Fauna of the Kyzylkain Svita (furnished by Dr. Shevyreva)

RODENTIA
CTENODACTYLIDAE Indet.; cited by Shevyreva, pers. com., 1981, as Chapattimyidae indet.

U.S.S.R.
KAZAKHSTAN S.S.R.
Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Lower Aksyir Subsvita **late Eocene**

Localities: Areal Site VI, Kiin-Kerish Mountain; Chernyy Irtysh River (Parom); Areal Site X, between the Kusto and Kyzylkain Rivers; junction of the Konurkura and Dzhamangora Rivers; Areal Site IV, Chaybulak River (Sopka Osobaya); Areal Site VIII, Bulkair Valley; Kenderlyk River (Mogila Sultan and/or Tabtym); Areal Site II, Kalmakpay River; Areal Site V, Aksyir River (Tagvi, Severnaya I and Ia); Chakpaktas River; Koksaldy River (Sunduk); Areal Site IX, Akkolka River; Akkezen' River (Ovrag Korzhumbay); Areal Site III, Ul'ken-Ulasty River (Prirechnoye)

A fossil mammal was first discovered in the lower part of the Aksyir[42] Svita in 1927 by M. F. Neyburg in the Dzhamangora River valley. A. A. Borisyak identified the specimen as a vertebra

40 Kyzylkain = red birch hill.
41 Zheltye Pyatna = yellow spots.
42 Aksyir = white cow.

Source : MNHN, Paris

of a brontothere, which constituted the first occurrence of the group in the U.S.S.R. According to Borisyak it indicated an older age for the sediments than those that had yielded the celebrated indricothere fauna. Many localities were discovered later in this level by different authors; the principal sites are listed above.

On the western slopes of Kiin-Kerish Mountain the first discoveries in the lower sands of the Aksyir Svita were made in the 1960's by M. D. Biruykov (*Kiinkerishella* and others). In 1964, Borisov found a partial skeleton (described by Belyayeva (1971) as *Zaisanamynodon*) at the top of the sands, 5-6 m from the base of the svita. Another rhinocerotoid was discovered by M. A. Khmetiyev in 1983, 10 m from the base, accompanied by a paleoflora. The lower part of the Aksyir Svita is situated between the Kershi beds (questionably middle or late Eocene) and the middle part of the Aksyir Svita, and is about 14 m thick.

Some comments are called for concerning the article by Gabunia and Biryukov (1978) describing *Kiinkerishella*. At the time of the discovery of the remains of this animal, the beds containing it were called the Turanga Svita. Since then, this series ("suite") has been divided into the Chaybulak, Kyzylkain and Aksyir Svitas. *Kiinkerishella* came from the lower part of the latter. It was found in the Kiin-Kerish Hills at "sopka" (hillock) K, in an area now called Kiin-Kerish I. Various early authors (Borisov, 1963; Bazhanov and Kostenko, 1964; Biryukov and Kostenko, 1965) cited the presence of *Plesiadapis* in the Zaysan Depression; this was based on the misidentification of *Kiinkerishella*.

In the northeast part of the Zaysan Basin, Borisov (pers. com., 1984) noted the presence of fossil mammals in the lower part of the Aksyir Svita at a locality called Parom[43] on the left bank of the Irtysh River.

On the right bank of the Kusto River, where it leaves the Manrak Range, the lower part of the Aksyir Svita (about 20 m in thickness) is situated between the middle part of the svita and the Kyzylkain and all three are vertical. Mammalian fossils are found principally in its upper parts, at the level of the thickest indurated sand. Mammals were first found here by Biryukov in the 1950's and 60's (see Bazhanov & Kostenko, 1964).

In the valleys of the Konurkura[44], Dzhamangora and Chaybulak Rivers, the thickness of the lower part of the Aksyir is 10-12 m. It dips gently toward the northeast and is situated between the Chaybulak Svita (the Kyzylkain is lacking) and the middle part of the Aksyir. Mammalian fossils are rather rare in these areas.

The Mogila Sultan locality is on the right bank of the Kenderlyk River, where it comes down from the Saykan Range and enters the Zaysan Basin. It is about 10-12 km southeast of the town of Przheval'skoye.

On the right bank of the Aksyir River mammal localities were discovered in the 1960's and 70's by Chkhikvadze and Shevyreva. These sites (Tagvy, Severnaya[45] I and Severnaya Ia) are found either at the base or in the lower part of the cuesta on the northern flank of the first Aksyir anticline. The lower part of the Aksyir Svita is 15-16 m thick here.

In the Kenderlyk Basin vertebrate remains are often associated with coprolites (as in the Zaysan Basin) and both are present in nearly all the outcrops of the lower part of the Aksyir Svita; the thickness of the latter varies between 5 and 15 m. Important collections have been made in the 1960's and 70's by Chkhikvadze and Shevyreva, upstream along the Akkolka River and on the Akkezen'[46] River; Korzhumbay stream is a right tributary of the latter. The lower part of the Aksyir Svita is nearly horizontal and lies between the middle part of the svita and the Kyzylkain Svita.

Mammalian evidence concerning the age of the Lower Aksyir subsvita is indecisive. The elements that tend to indicate an Oligocene assemblage are not irrefutable. On the other hand, there is no definite reason for referring it to the late Eocene. We will tentatively follow Soviet workers who place these beds in the late Eocene, while waiting for more extensive collections.

43 Parom = ferry.
44 Konurkura = red-brown, slightly blackish color.
45 Severnaya = north, referring to the north cuesta.
46 Akkezen' = white narrow canyon.

Source : MNHN, Paris

Fauna of the lower Aksyir Subsvita

(furnished by Dr. Shevyreva, Prof. Gabunia and Dr. Gureyev)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

RODENTIA

CYLINDRODONTIDAE Indet.; cited by Shevyreva, pers. com., 1981

CTENODACTYLIDAE — *Ardynomys glambus* Shevyreva, 1972
(= *Petrokozlovia glambus* (Shevyreva, 1972) *in* Hussain *et al.*, 1977
— Ctenodactylidae indet.; cited by Shevyreva, pers. com., 1981

CRICETIDAE Indet.; cited by Shevyreva, pers. com., 1981

DIPODIDAE Indet.; cited by Shevyreva, pers. com., 1981, as Zapodidae

ISCHYROMYOIDEA? FAMILY Indet.; cited by Sbevyreva, pers. comm., 1981

CONDYLARTHRA

PAROXYCLAENIDAE — *Kiinkerishella zaisanica* Gabunia & Biryukov, 1978

PERISSODACTYLA

AMYNODONTIDAE — *Zaisanamynodon*[47] *borisovi* Belyayeva, 1971

ARTIODACTYLA

ENTELODONTIDAE — *Eoentelodon* sp.; cited by Gabunia, pers. com., 1981

ANTHRACOTHERIIDAE — cf. *Anthracokeryx* sp.; cited by Gabunia, 1977
— Anthracotheriidae indet.; cited by Gabunia, pers, com., 1981

LEPTOMERYCIDAE[48] — *Archaeomeryx* sp.; cited by Gabunia, 1977

HELOHYIDAE — *Gobiohyus* sp.; cited by Gabunia, 1977

Lat. 43° 22′ N, approx.
Long. 132° 10′ , approx.

U.S.S.R.
PRIMORSKYI TERRITORY
("Maritime Province")
("Far East Province")

Uglov Svita **late Eocene**
Locality: Artëm

The discovery of Paleogene mammals in the Far East of the USSR (in the so-called Maritime Province) was made in 1952 in one of the coal mines of Artëm City near Vladivostok. They were of particular importance at the time as they represented the oldest Tertiary mammals within the USSR. The fossil remains were excavated by the mine workers and members of the Paleontological Institute of the Academy of Sciences of the USSR. Due to the difficult conditions not all of the material could be recovered.

The small lens-like accumulation of disartic-

47 This genus may be synonymous with *Gigantamynodon* Gromova, 1954, according to Wall & Manning, 1986.
48 *Fide* Webb & Taylor, 1980.

Source : MNHN, Paris

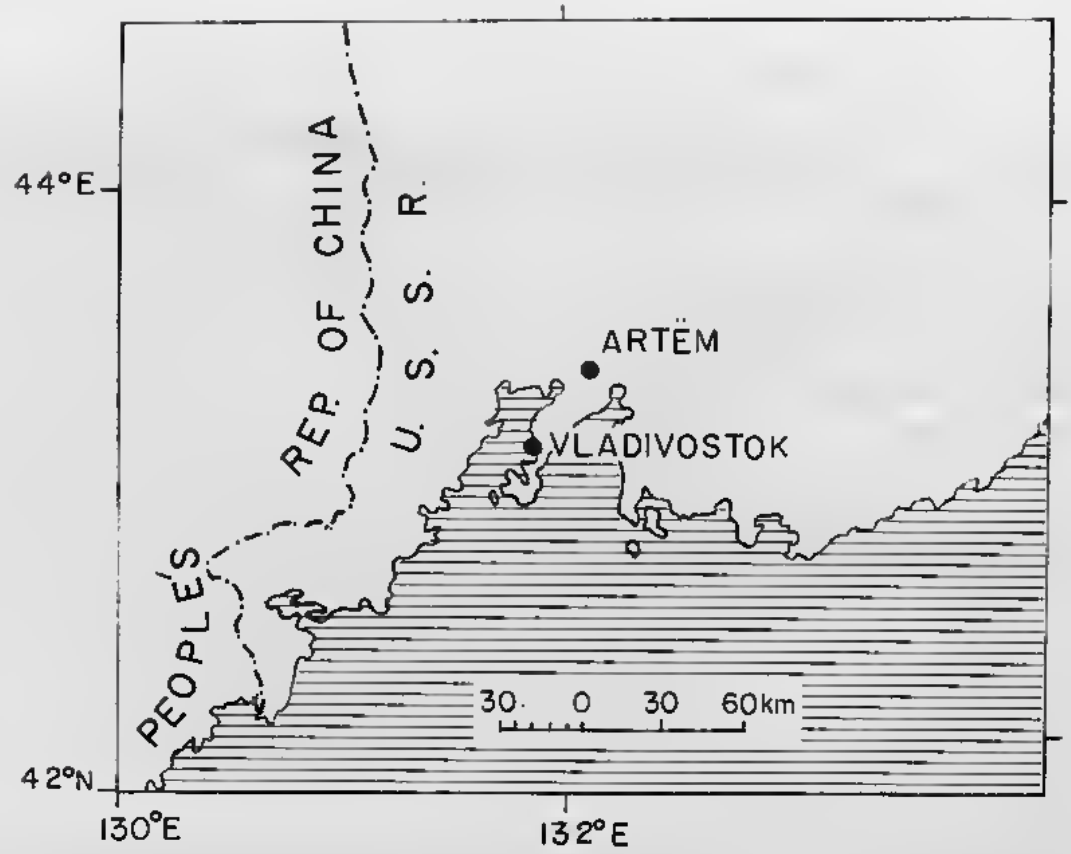


FIG. 136. — Regional map showing the placement of Artëm with respect to the city of Vladivostok, Primorskyi Territory. Modified from the Atlas Mira, Moscow, 1954.

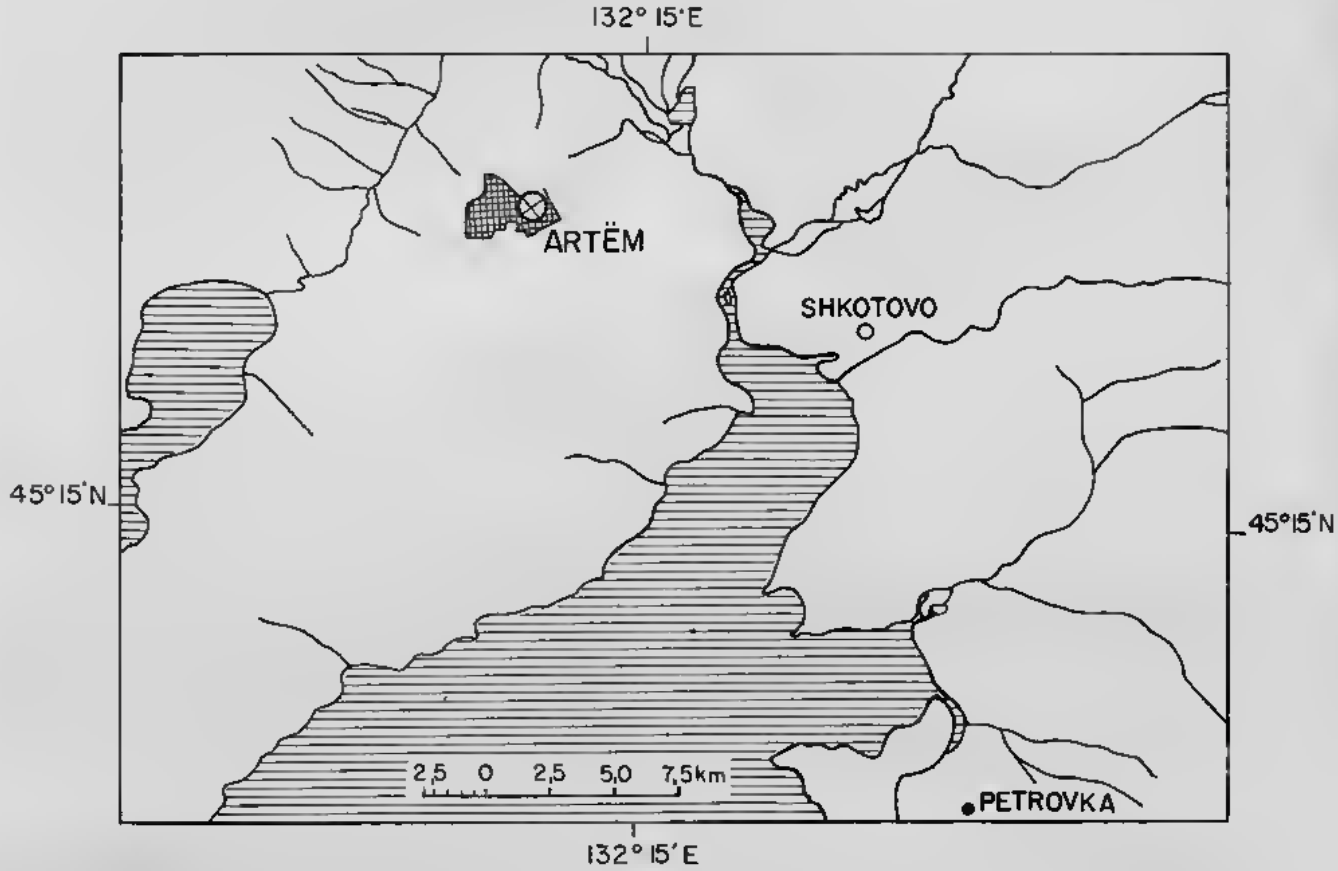


FIG. 137. — Artëm and its environs, Primorskyi Territory. The coal mines were within the city limits, which have expanded considerably since the original drawing of the above map. Modified from a map provided by G. V. Shkurkin.

Source : MNHN, Paris

ulated bones occurred in a seam of brown coal and carbonaceous shale 4 m in thickness, with an area of about 20 square meters at a depth of 150 m. Isolated bones were also found in a series of places nearby. Most of the fossil material was situated at the base of the seam in the carbonaceous shale. The bone was of poor conservation and difficult to separate from the matrix; they had, moreover, undergone considerable flattening and deformation. In fact, due to the degraded condition of the enclosing bone it was possible to collect little more than the teeth. The material recovered represented nearly exclusively various members of perissodactyl families; small carnivores, however, were also cited by Trofimov (1953) and at the time he wrote, not all the fossils had been prepared.

Late in the Eocene a series of basins formed in the Far East Province of the USSR in which sandy clay and coal-bearing deposits accumulated. According to Baskakova *et al.* (1972), the amount of coal decreases with the distance from the center to the periphery of the basins, where it become more silty. The Uglov Svita unconformably overlies Mesozoic rocks and is conformably overlain by the late Oligocene Nadezhda[49] Svita. Its thickness is 500-700 m.

The Uglov Svita is considered to be of late Eocene to early Oligocene age; the part containing the mammal remains is regarded as late Eocene, based largely on the stage of evolution of the latter. Since the conformably overlying Nadezhda Svita is stated to be late Oligocene, either it or the Uglov Svita must have a middle Oligocene component.

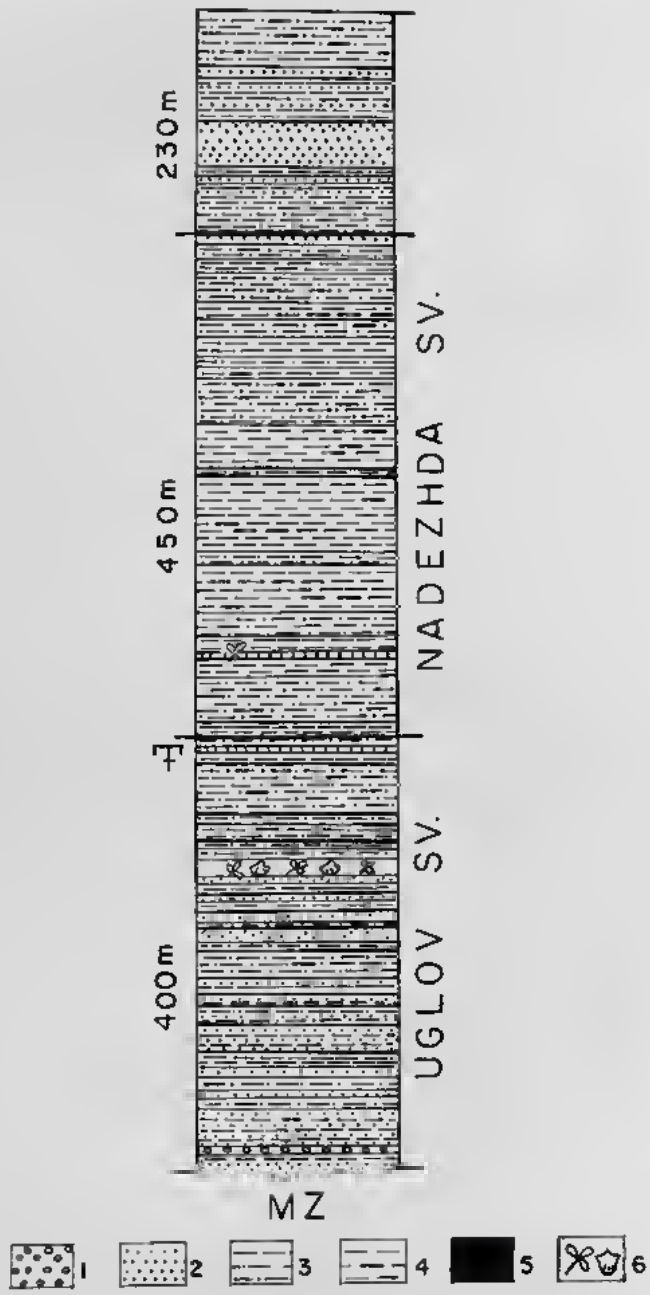


FIG. 138. — Section at Arlëm, Primorskyi Territory: **1.** pebbles and conglomerates; **2.** sands and sandstone; **3.** silts and pelites; **4.** clays and claystone; **5.** coal and coaly claystone; **6.** remains of flora and invertebrate fauna. Modified from Baskakova *et al.*, 1972.

Fauna of the Uglov Svita

CARNIVORA Indet.; cited by Trofimov, 1953

PERISSODACTYLA

BRONTOTHERIIDAE — *Rhinotitan orientalis* Yanovskaya, 1957, V.P. (3)

49 Nadezhda = hope.

Source : MNHN, Paris

HYRACODONTIDAE — *Juxia borissiaki* (Belyayeva, 1959), Lucas *et al.*, 1981
(= *Foestercooperia borissiaki* (Belyayeva, 1959), Belyayeva *et al.*, 1974)
(= *Eotrigonias borissiaki* Belyayeva, 1959)

AMYNODONTIDAE — *Procadurcodon orientalis* Gromova, 1960c

Lat. 41° 36′ N, approx.
Long. 42° 22′ E, approx.

U.S.S.R.
GEORGIAN S.S.R.
Adzharia S.S.R.

Adigueni Svita **late Eocene**
Locality: Vani

In 1957 a femur of a terrestrial mammal was discovered in southwest Georgia by a geologist near the small stream of Vani (Fig. 221, p. 389). The sediments containing it are marine and dated as late Eocene. The presence of a chalicothere, as the specimen was determined by Gabunia, in these deposits of eastern Adzharia indicates the proximity of a landmass. The Transcaucasian landmass is viewed by Gabunia as a region of great importance along the migration route between Asia and Europe; this single specimen is a minimal testimony of the fauna that inhabited the area in the Eocene.

Fauna of the Adigueni Svita at Vani

PERISSODACTYLA
CHALICOTHERIIDAE Indet.; cited by Gabunia, 1957

LATE EOCENE

Composit List

(**Al**: Alag-Tsav; **Art**: Artêm; **Chang**: Changxindian; **Chu**: Chugouyu; **Gon**: Gonosawa; **Het**: Heti; **Hos**: Hôsan; **Hun**: Hunshuihe; **Jg**: Junggar; **Jiy**: Jiyuan; **Kzn**: Kyzylkain; **Lak**: Lower Aksyir; **Mel**: Melawi; **Pd**: Pondaung; **Sh**: Shara Murun; **Tim**: Timor; **Ube**: Ube; **Wld**: Wulidui. (Naduo not included))

INSECTIVORA
ERINACEIDAE
Chang — *Tupaiodon*? sp.

INSECTIVORA Incertae sedis
Het — *Ictopidium lechei*
Lak — Insectivora indet.

PRIMATES
Family uncertain
Het — *Hoanghonius stehlini*
Pd — *Pondaungia cottteri*
Pd — *Amphipithecus mogaungensis*

Source : MNHN, Paris

PANTODONTA
CORYPHODONTIDAE
Chang — *Eudinoceras*? sp.
TILLODONTIA
TILLOTHERIIDAE
Het — *Adapidium huangoensis*
LAGOMORPHA
LEPORIDAE
Sh — *Shamolagus medius*
Sh — *Gobiolagus tolmachovi*
Chu — Palaeolaginae indet.
OCHOTONIDAE
Sh — *Desmatolagus* sp.
RODENTIA
CYLINDRODONTIDAE
Lak — Cylindrodontidae Indet.
CRICETIDAE
Het — "*Cricetodon*" *schaubi*
Lak — Cricetidae indet.
CTENODACTYLIDAE
Lak — *Ardynomys glambus*
Het, Chu, Kzn, Lak — Ctenodactylidae indet.
Het, Sh, Chu, Jih — *Yuomys cavioides*
Chu — *Yuomys* sp.
DIPOPIDAE
Het — *Parasminthus* sp.
Lak — Dipodidae indet.
MIXODONTIA
EURYMYLIDAE
Chang — *Hypsimylus beijingensis*
CARNIVORA
MIACIDAE
Chang — *Miacis* sp.
CANIDAE
Het — *Chailicyon crassidens*
Chang — Canidae indet.
VIVERRIDAE?
Pd — Viverridae? indet.
CREODONTA
HYAENODONTIDAE
Sh — cf. *Propterodon morrisi*
Het — *Hyaenodon yuancluensis*
Al — *Hyaenodon* sp.
Het — *Pterodon* cf. *dahkoensis*
Sh — "*Pterodon*" *hyaenoides*
CONDYLARTHRA
MESONYCHIDAE
Hos — "*Harpagolestes*" *koreanicus*
Sh — "*Olsenia mira*"
Het — *Honanodon hebetis* (lower part of Heti)
PAROXYCLAENIDAE
Lak — *Kiinkerishella zaisanica*

Source : MNHN, Paris

PERISSODACTYLA

BRONTOTHERIIDAE

Pd	— *Metatelmatherium*? *browni*
Pd	— *Metatelmatherium*? *lahirii*
Pd	— *Sivatitanops cotteri*
Pd	— *Sivatitanops birmanicum*
Pd	— *Sivatitanops*? *rugosidens*
Sh	— *Telmatherium*? sp.
Sh	— *Manteoceras*? sp.
Sh	— *Rhinotitan kaiseni*
Het, Sh	— *Rhinotitan mongoliensis*
Sh	— *Rhinotitan andrewsi*
Art	— *Rhinotitan orientalis*
Sh	— *Pachytitan ajax*
Hos	— *Protitan*? *koreanicum*
Sh	— *Titanodectes minor*
Sh	— *Titanodectes ingens*
Hun	— Brontotheriidae indet.

EOMOROPIDAE

Het	— *Eomoropus quadridentatus*
Het, Chu	— *Litolophus major*

CHALICOTHERIIDAE

Sh	— *Schizotherium* sp.

ISECTOLOPHIDAE Indet.

Het.	

DEPERETELLIDAE

Pd	— *Diplolophodon birmanicum*
Het	— *Diplolophodon similis*
Sh	— *Deperetella cristata*
Het	— *Deperetella depereti*
Sh	— *Teleolophus medius*? (presence here doubtful)

HELALETIDAE

Hos	— *Colodon horosimai*
Hos, Ube	— *Colodon*? *grangeri*

LOPHIALETIDAE

Sh	— *Lophialetes* sp. (stratigraphic position uncertain)
Chu	— *Breviodon* sp.

LOPHIALETIDAE?

Sh	— *Rhodopagus minimus*
Het	— *Rhodopagus*? sp.

TAPIROID Indet.

Pd	— *Indolophus guptai*

HYRACODONTIDAE

Het	— *Prohyracodon* cf. *meridionale*
Sh	— *Triplopus*? *progressus*
Chu	— *Forstercooperia* sp.
Wld	— *Imequincisoria mazhuangensis*
Wld	— *Imequincisoria micracis*
Chang	— *Imequincisoria* sp.
Wld	— *Imequincisoria*? sp.
Sh, Art, Wld	— *Juxia borissiaki*

RHINOCEROTOIDEA Indet.

Hos	— "*Lophialetes*" *tokunaga*

Source : MNHN, Paris

AMYNODONTIDAE

Jih — *Lushiamynodon obesus*
Sh — *Lushiamynodon sharamurenensis*
Wld — cf. *Lushiamynodon* sp.
Sh, Het — *Sharamynodon mongoliensis*
Het — *Sharamynodon mongoliensis*?
Sh — *Caenolophus obliquus*
Sh — *Caenolophus promissus*
Het — *Caenolophus* cf. *promissus*
Hun — *Caenolophus* sp.
Hos — *Caenolophus*? *makii*
Sh — *Sianodon ulausuensis*
Jih — *Sianodon chiyuanensis*
Wld, Het, Jih — *Sianodon sinensis*
Het — *Sianodon mienchiensis*
Sh — *Sianodon* sp.
Pd — *Paramynodon birmanicus*
Pd — *Paramynodon cotteri*
Sh — *Gigantamynodon promisus*
Wld — *Gigantamynodon* sp.
Sh — cf. *Cadurcodon* sp.
Art — *Procadurcodon orientalis*
Gon, Ube — *Amynodon watanabei*
Het — *Amynodon* sp.
Het — *Amynodon*? sp.
Lak — *Zaisanamynodon borisovi*
Chang — Amynodontidae? indet.

ARTIODACTYLA

FAMILY Indet.

Het — *Dichobune*? sp.

ENTELODONTIDAE

Lak — *Eoentelodon* sp.

ANTHRACOTHERIIDAE

Sh — *Ulausuodon parvus*
Pd — *Anthracohyus choeroides*
Pd — *Anthracokeryx moriturus*
Pd — *Anthracokeryx birmanicus*
Pd — *Anthracokeryx tenuis*
Het — *Anthracokeryx dawsoni*
Het — *Anthracokeryx sinensis*
Het — *Anthracokeryx* cf. *sinensis*
Pd — *Anthracokeryx*? *lahirii*
Sh, Lak — cf. *Anthracokeryx* sp.
Pd — *Anthracothema pangan*
Pd — *Anthracothema rubricae*
Het — *Anthracothema minima*
Tim — *Anthracothema verhoeveni*
Het — *Anthracosenex ambiguus*
Jg — *Bothriodon* sp. (presence doubtful)
Jg — cf. *Probrachyodus* sp.
Hun, Mel — Anthracotheriidae indet.

LEPTOMERYCIDAE

Sh, Chu, Al — *Archaeomeryx optatus*
Hun, Lak — *Archaeomeryx* sp.

Source : MNHN, Paris

HELOHYIDAE

Lak — *Gobiohyus* sp.
Het — *Indohyus? yuanchuensis*

TRAGULOIDEA

Pd — *Indomeryx cotteri*
Pd — *Indomeryx arenae*

Lat. 23° 35′-23° 50′ N
Long. 106° 35′-107° 10′ E

Fig. 2, n° 23

CHINA

GUANGXI ZHUANG AUTONOMOUS REGION

Bose and Yongle Basins

Naduo Fm. **Late Eocene?**

The Bose and Yongle Basins have been treated earlier with the discussion of the lower sediments they contain (see Dongjun Fm.).

The Oligocene Gongkang Fm. overlies the Eocene deposits and will be discussed later. Conformably underlying it is the Naduo Fm., which has three members: the upper, or "coal" member, is principally composed of green-gray mudstones intercalated with sandy mudstones and contains lenses of gravel and some coal; its thickness is from 188-245 m. The middle member is unfossiliferous brown and dark brown mudstone, with a thickness of 250 m. The lower "coal" member is mostly green-gray silt and mudstone and sandy mudstone with occurrences of coal; its thickness is 125 m. Conformably below is the Dongjun Formation.

While the "Naduo" fauna, as established in the literature, showed that correlation with the Shara Murun Fm. was probable, and indicated a significant number of genera in common with the Pondaung fauna, these relationships are now regarded with doubt. The presence in the Bose and Yongle Basins of *Paramynodon, Anthracokeryx* and *Anthracothema* is questioned by D. E. Savage (pers. com., 1985).

Already, in a revised faunal list proposed by Xu (1982), various changes can be seen with respect to the taxa cited previously by Tang *et al.* (1974) and Tang (1978a). *Metatelmatherium* cf. *browni, Deperetella* sp., *Forstercooperia* sp., *Heothema* sp., and Choeropotamidae n. gen. all disappear. *Heothema chengbiensis, H. media* and *H. angusticalxia* originally described as coming from the Gongkang Fm., are attributed (erroneously) to the Naduo by Tang & Qiu (1979); *Huananothema imparilica* and *Heothema bellia*, originally described from the Naduo Fm. are reconfirmed, in opposition to their attribution to the Gongkang Fm. by Tang & Qiu. But it is now possible that none of these taxa are, in reality, from the Naduo Formation.

This confusion in stratigraphical origin could result from the fact that local geologists refer to certain beds as lower Gongkang Fm., while other workers consider them as upper Naduo Fm.

Savage, Zhai, Tong & Ciochon (manuscript, 1985) state that, according to field studies made in 1983, the Naduo Fm. is principally known as a subsurface stratum and presents only a few outcrops in the southeastern part of the Bose Basin. Furthermore, they suspect that most, if not all, of the so-called Naduo fauna originated in the overlying Gongkang Fm. since the Naduo Fm. does not appear to crop out in areas where collections of fossil mammals were made.

Source : MNHN, Paris

Fauna of the Naduo Fm. (as published)

CARNIVORA

URSIDAE
- — *Pachycynodon*? n. sp.; cited by Tang & Qiu, 1979
- — *Cephalogale* n. sp.; cited by Tang & Qiu, 1979
- — cf. *Cephalogale* sp.; cited by Tang & Qiu, 1979

AMPHICYONIDAE
- — *Guangxicynodon sinocaliforniae* Zhai *et al.*, MS, 1985

PROCYONOIDEA Indet.
- — *Eodesmatodon spanios* Zheng & Chi, 1978, V.P. (2); suprageneric identification by D.E. Savage, pers. com., 1984

CREODONTA

HYAENODONTIDAE
- — *Propterodon*? sp.; cited by Tang & Qiu, 1979

CONDYLARTHRA

MESONYCHIDAE
- — *Guilestes acares* Zheng & Chi, 1978, V.P. (2)
- — *Guilestes* cf. *acares* Zheng & Chi, 1978; cited by Zheng & Chi, 1978, V.P. (2)
- — cf. *Harpagolestes* sp.; cited by Zheng & Chi, 1978, V.P. (2)

PERISSODACTYLA

EOMOROPIDAE
- — *Eomoropus* cf. *quadridentatus* Zdansky, 1930; cited by Zhang, 1976, V.P. (2)

RHINOCEROTIDAE?
- — *Huananodon hui* You, 1977, V.P. (1)
- — *Guixia simplex* You, 1977, V.P. (1)

AMYNODONTIDAE
- — *Caenolophus* sp.; cited by Tang *et al.*, 1974, V.P. (4)
- — *Paramynodon* sp.; cited by Tang & Qiu, 1979
  (= *Paramynodon* cf. *birmanicus* Pilgrim & Cotter, 1916; cited by Tang *et al.*, 197, V.P. (4), but from an earlier source)
  (= Amynodontidae ident.; cited by Xu, 1966, V.P. (2))

ARTIODACTYLA

ANTHRACOTHERIIDAE
- — *Anthracothema rubricae* (Pilgrim & Cotter, 1916) Pilgrim, 1928, cited by Tang *et al.*, 1974, V.P. (4)
  (= *Anthracohyus rubricae* Pilgrim & Cotter, 1916)
- — *Anthracokeryx birmanicus* Pilgrim & Cotter, 1916; cited by Tang *et al.*, 1974, V.P. (4)
- — *Anthracokeryx moriturus* Pilgrim, 1928; cited by Tang & Qiu, 1979
- — *Anthracokeryx* sp.; cited by Tang *et al.*, 1974, V.P. (4)
  (= *Anthracokeryx* cf. *bambusae* Pilgrim, 1928, *in* Qiu Z.-d., 1977, V.P. (1), but this species = *A. birmanicus* or *tenuis*, *in* Colbert 1938. *Anthracokeryx* cf. *bambusae* is still cited by Tang & Qiu, 1979)
- — "*Bothriodon*"[1] *chyelingensis* Xu, 1977b, V.P. (3)
- — *Heothema bellia* Tang, 1978a, V.P. (1)
- — *Huananothema imparilica* Tang, 1978a, V.P. (1)
- — *Heothema media* Tang, 1978a, V.P. (1)

SUIDAE
- — n. gen.; cited by Tong *et al.*, MS, 1985

TAYASSUIDAE
- — n. gen. A and B; cited by Tang & Qiu, 1979

GELOCIDAE
- — *Notomeryx youjiangensis* (Qiu, 1978) Tong *et al.*, MS, 1985
  (= *Indomeryx youjiangensis* Qiu, 1978, V.P. (1))

1 Too primitive to be *Bothriodon*, according to Dineur, 1982.

Source : MNHN, Paris

(= *Indomeryx* n. sp.; cited by Tang *et al.*, 1974, V.P. (4))
(= *Indomeryx cotteri* Pilgrim, 1928; cited by Tang *et al.*, 1974, V.P. (4), *in parte*)
(= *Notomeryx besensis* Qiu, 1978, V.P. (1))

— *Notomeryx n. sp.; cited by Tong et al.*, MS, 1985
(= *Indomeryx cotteri* Pilgrim 1928; cited by Tang *et al.*, 1974, V.P. (4), *in parte*)

Lat. 23° 35'-23° 50' N
Long. 106° 35'-107° 10' E

Fig. 2, n° 23

CHINA
Guangxi Zhuang Autonomous Region
(Kwangsi)
Bose and Yongle Basins

Gongkang Fm. **late Eocene-early Oligocene?**

More details of the Bose and Yongle Basins are given under the late Eocene(?) Naduo Formation.

The Gongkang Formation consists mostly of yellowish or grayish green and variegated mudstone, sandy shale and sandstone, varying in thickness from 1,300 to 1,450 m. It overlies conformably the Naduo Formation and is overlain by the Pliocene to Quaternary Changsheling[2] Formation.

This formation is considered by Tang and Qiu (1979) and by Xu (1982) to be only early Oligocene in age; this is opposed to the opinion expressed by Tang et al. (1974) wherein the formation was thought to include late Eocene sediments at its base.

On the basis of the published information presently available the similarity of the Gongkang fauna to that of the Naduo is striking, with *Huananodon, Guixia, Anthracokeryx* and *Heothema* in common. The presence of *Bothriodon*, usually taken to indicate the Oligocene, can be discounted here since the species *chyelingensis* does not appear to be referable to that genus. However, according to Coombs (1978), *Schizotherium nabanensis* is scarcely, if at all, distin-

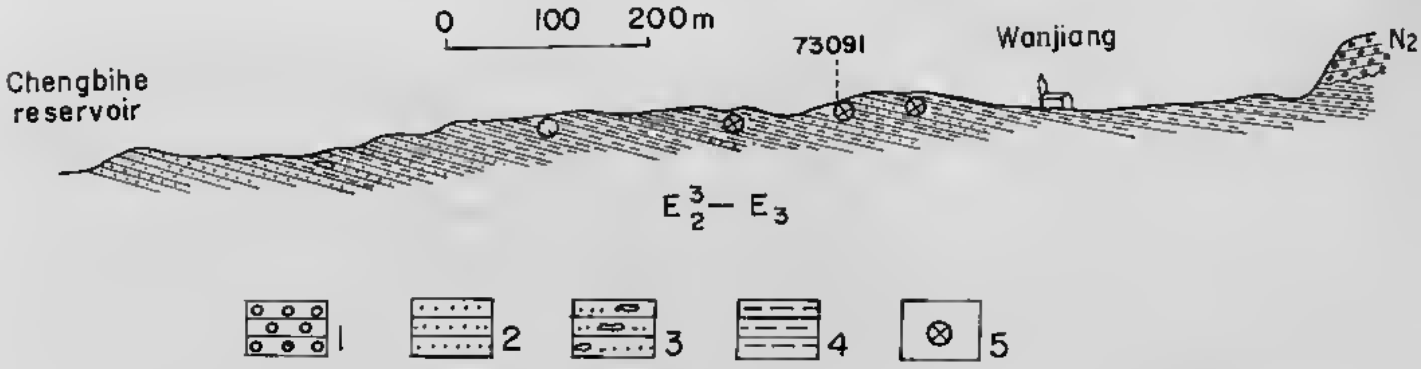


FIG. 139. — Cross section through the Yongle Basin (Guangxi) between Wanjiang and the Chengbihe Reservoir showing the sandstone, sandy mudstone and mudstone of the Gongkang Fm. The Pliocene conglomerate of the Changsheling Fm. crops out in the northeast. 1. conglomerate; 2. sandstone; 3. sandstone with concretions; 4 mudstone; 5. fossil mammal locality. Modified from Tang *et al.*, 1974.

2 Changsheling = long snake range.

Source : MNHN, Paris

guishable from the early Oligocene *S. avitum* of Ergilin-Dzo, and tayassuids are known in the Oligocene of both Europe and North America.

In view of the reported difficulty met in determining the stratigraphic source of the fossil mammals collected in the Bose and Yongle Basins and the supposition that apparently all of them are from the Gongkang Formation, we will regard the Naduo and Gongkang faunas as a single assemblage. Correlation of this assemblage remains difficult since the identification of many of the useful (not endemic to the region) forms has been doubted (*Pachycynodon, Propterodon, Hoplophoneus, Harpagolestes, Paramynodon, Anthracothema, Anthracokeryx* and *Bothriodon*). Those remaining include *Eomoropus* (middle-late Eocene), *Caenolophus* (middle-late Eocene), *Forstercooperia* (middle Eocene-early Oligocene) and *Schizotherium* (early Oligocene). Given the many uncertainties that surround this assemblage we prefer to date it no more accurately than late Eocene-early Oligocene.

Fauna of the Gongkang Fm. (as published)

CARNIVORA
- FELIDAE
  - — Machairodontinae n. gen.; cited by Tang & Qiu, 1979
  - — *Hoplophoneus*?; cited by Tang & Qiu, 1979

PERISSODACTYLA
- CHALICOTHERIIDAE
  - — *Schizotherium nabanensis* Zhang, 1976, V.P. (2)
  - — *Schizotherium* sp.; cited by Zhang, 1976, V.P. (2)
- HYRACODONTIDAE
  - — *Forstercooperia* n. sp.; cited by Tang *et al.*, 1974, V.P. (4)
- RHINOCEROTIDAE?
  - — *Huananodon hypsodonta* You, 1977, V.P. (1)
  - — *Guixia youjiangensis* You, 1977, V.P. (1)

ARTIODACTYLA
- ANTHRACOTHERIIDAE
  - — *Anthracokeryx kwangsiensis* Qiu, Z.-d., 1977, V.P. (1)
  - — *Anthracokeryx gungkangensis* Qiu, Z.-d., 1977, V.P. (1)
  - — *Anthracokeryx* sp.; cited by Tang *et al.*, 1974, V.P. (4)
  - — "*Bothriodon*"[3] *tientongensis* Xu Q., 1977b, V.P. (3)
  - — *Heothema media* Tang, 1978a, V.P. (1)
  - — *Heothema chengbiensis*[4] Tang, 1978a, V.P. (1)
  - — *Heothema angusticalxia* (misprinted as *H. angnsticalxia*) Tang, 1978a, V.P. (1)
- TAYASSUIDAE
  - — *Eopecarihyus* n. sp., Tong *et al.*, MS, 1985 (= Tayassuidae gen. indet.; cited by Xu, 1982)

Lat. 26° 14′ N
Long. 104° 06′ E

Fig. 2, n° 41

CHINA

YUNNAN PROVINCE

Xuanwei County

unnamed fm. — **late Eocene-early Oligocene**

Xuanwei[5], a large county in the northeastern part of Yunnan, is about 90 km to the north of Qujing. Paleontological investigation of this district is still lacking despite the existence of a

3 Morphologically this species is not referable to *Bothriodon*. Dineur, 1982.

4 *Heothema chengbiensis, H. media* and *H. angusticalxia* were described by Tang (1978) as coming from the Gonkang Fm. These taxa were reported (in error) instead as being from the Naduo Fm. by Tang & Qiu (1979), an error that was repeated by Xu (1982).

5 Xuanwei = declare the emperor's power.

Source : MNHN, Paris

beautiful indricothere molar that was found there (in 1979) by Zhang G.-t. and Wang C.-l., two geologists of the Chinese Academy of Geological Sciences.

It is said that the fossil-bearing beds are mainly purplish red sandstones and conglomerates with intercalating mudstones. No detailed stratigraphical information, nor even the locality name, is available.

Primitive small indricotheres have usually been found in latest Eocene or early Oligocene sediments in China; this specimen is probably of the same age.

Fauna of the unnamed formation of Xuanwei County

PERISSODACTYLA

HYRACODONTIDAE — *Indricotherium parvum* Chow, 1958, V.P. (4); cited by Zhang, 1980c, V.P. (4)

Lat. 22° 45′-23° 00′ N
Long. 108° 10′-108° 40′ E

Fig. 2, n° 42

CHINA

GUANGXI ZHUANG AUTONOMOUS REGION

(KWANGSI)

NANNING BASIN

Yongning Fm. **early Oligocene**

Locality: Liantang

The Nanning Basin is about 63 km long, with a width of less than 20 km, and is elongated in a NEE-SWW direction; Nanning, the capital city of the autonomous region, is located in its southwest part. The basin is one of those rare areas in China that were investigated as early as the last century; in 1898-1899, M. A. Leclerc, a French geologist, visited the region. Early in this century, while surveying the geology and ore resources of southern Guangxi, Zhu T.-g. (1928) of the Geological Survey of China, named the lignite beds of the Nanning Basin the Yongning[6] Formation. Based on gastropod fossils identified by the Swedish paleontologist H. J. Odhner (1930), the age of the Yongning Formation was long thought to be Pliocene. With the recovery of early Tertiary mammals in the neighboring Bose and Yongle Basins (about 120 km to the northwest), an increasing number of geologists argued against the gastropod dating of the formation. Field work in 1974, 1979 and 1980 by members of the Museum of the Guangxi Zhuang Autonomous Region led to the discovery of fossil vertebrates of Oligocene age in Nanning Basin near the village of Liantang[7] and the Lilu Coal Mine. The description (Zhao, 1981) of an anthracothere from the lowest member of the Yongning Formation provided an important argument in favor of an older age.

The early Tertiary sediments of the Nanning[8] Basin are divided into three formations; the youngest, the Yongning Fm., is subdivided into three members: the top and bottom members consist of lignitic swamp deposits (principally sandy clay) and have furnished crocodiles, turtles and anthracotheres. The lower member (about 190 m thick) is mostly gray mudstone and silts and contains 10-12 lignite beds. The middle

6 Yongning = place name.
7 Liantang = lotus pond.
8 Nanning = southern peace.

Source : MNHN, Paris

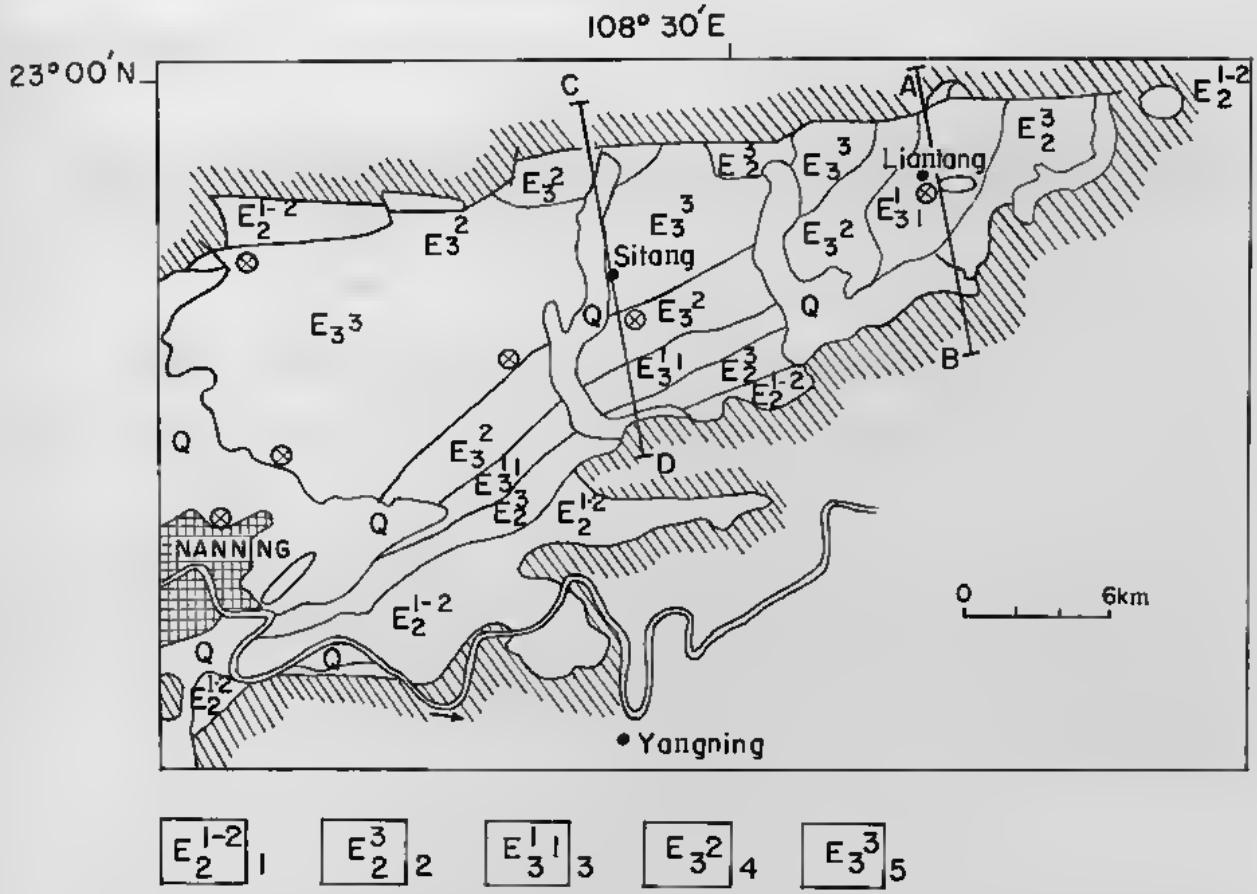


FIG. 140. — Outcrop map of the Nanning Basin, Guangxi. The Paleogene or Quaternary sediments of the basin are surrounded by Cambrian and Devonian rocks. 1. early to middle Eocene " red stone " fm.; 2. late Eocene? Naduo Fm.; 3. early Oligocene? Yongning Fm.; lower member; 4. Yongning Fm.; middle member; 5. Yongning Fm.; upper member. Modified from Zhao, 1981.

member (also about 190 m thick) is lacustrine in origin and consists of alternating beds of gray and greenish mudstone and sandstone and is considered as undifferentiated Oligocene in age. The upper member (about 264 m thick) is gray or grayish green mudstone with beds of lignite. The total thickness of this formation is more than 643 m.

The Naduo Formation, conformably underlying the Yongning Fm. and the next oldest in the sequence, is composed of 143-228 m of lignitic lake and swamp deposits. It is regarded as late Eocene to early Oligocene in age. The lowest, or "red stone" formation, consists of dark red and yellowish brown coarse sandstones, sandy mudstone and conglomerates that range

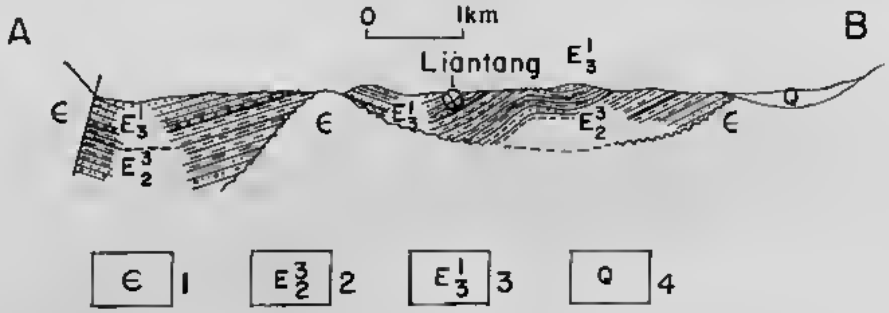


FIG. 141. — Cross section (A-B) through the northern part of the Nanning Basin, Guangxi. 1. Cambrian; 2. late Eocene? Naduo Fm.; 3. early Oligocene? Yongning Fm.; 4. Quaternary. Modified from Zhao, 1981.

Source : MNHN, Paris

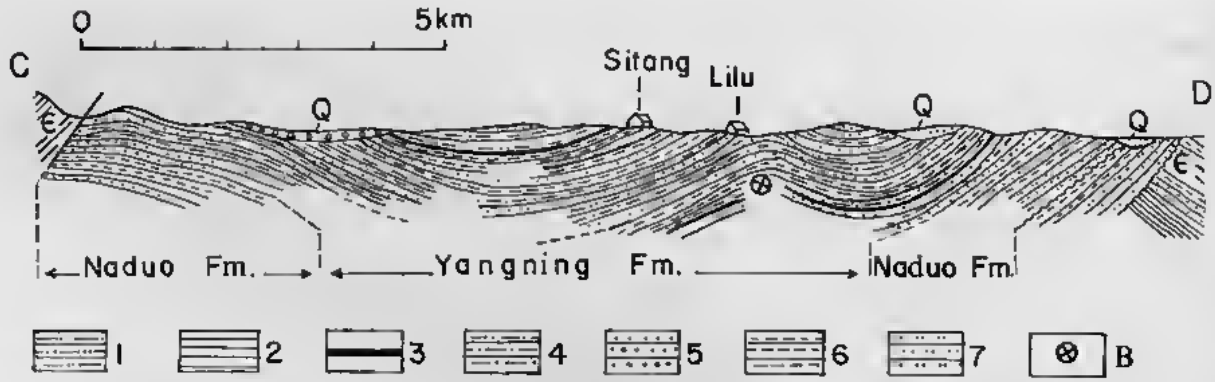


FIG. 142. — Cross section taken between C and D on the outcrop map of the Nanning Basin, Guangxi. 1. argillaceous siltstone; 2. shale; 3. coal; 4. sandy mudstone; 5. sandstone; 6. mudstone; 7. siltstone; 8 fossil mammal locality; Q = Quaternary. Modified from Zhao, 1983.

from 100 to 220 m in thickness; it overlies early Paleozoic rocks. An early to middle Eocene age for it has been proposed, but so far fossil mammals are only known in the lowest part of the Yongning Fm. Quaternary deposits partially overlie the latter, which otherwise forms the surface of the basin.

The age of the lowest part of the Yongning Fm. was based on the stage of evolution of the anthracotheres and their similarity to species from the Gongkang Fm. of the Bose and Yongle Basins.

Fauna of the Yongning Fm.

ARTIODACTYLA

ANTHRACOTHERIIDAE

— *Heothema nanningensis* Zhao, 1981, V.P. (3)
— *Heothema youngi* Zhao, 1983, V.P. (3)

Lat. 25° 43′ N
Long. 104° 25′ E

Fig. 2, n° 40

CHINA
GUIZHOU PROVINCE
Panxian County
Shinao Basin

Shinao Fm. **early Oligocene**

The first discovery of Paleogene fossil mammals in Panxian[9] County of Guizhou Province was made by Mao J.-z. in 1978 and the localities were exploited by IVPP teams in 1980.

The Shinao[10] Basin is situated in southwestern Guizhou and in adjoining eastern Yunnan. It is about 5 km long and is .2 to 2 km wide. Its area is less than 10 square kilometers and the sedi-

9 Panxian = Pan County.
10 Shinao = stone brain.

Source : MNHN, Paris

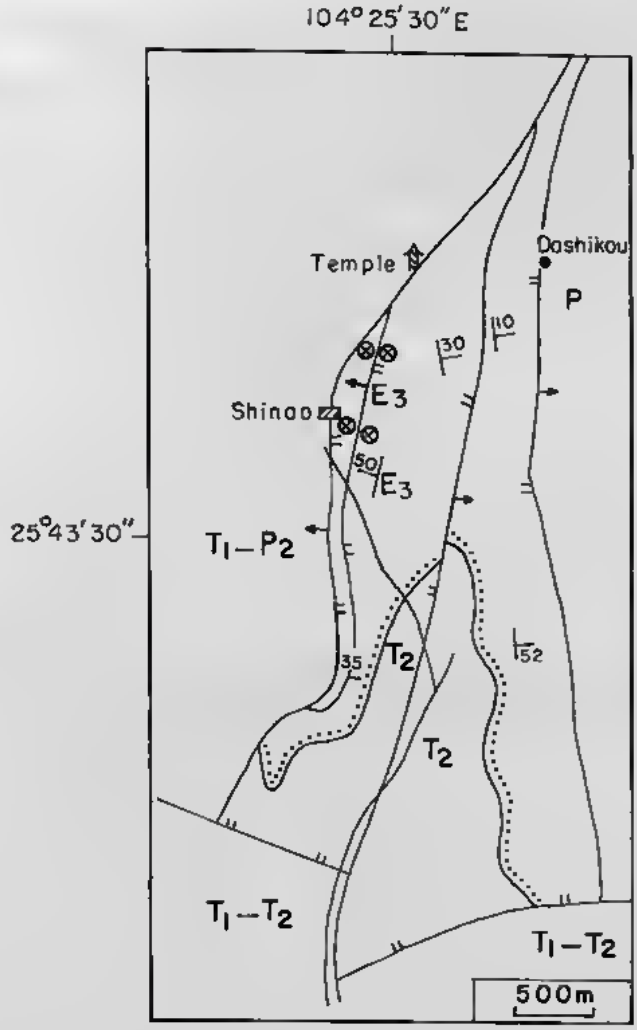


FIG. 143. — Sketch map showing the geology of the Shinao Basin, Guizhou Province. P. Permian; T_{1-2}. early and middle Triassic; T_2. middle Triassic Guanling Fm.; E_3. Shinao Fm. Modified from a map provided by Mao J.-z.

ments filling it are mainly calcareous or silty mudstones and limey conglomerates, containing, in the middle part, thin-layered lignite and gray coaly mudstone, for which local geologists have proposed the name Shinao Fm.

The sediments in the Shinao Basin were seriously disturbed by faults. The section drawn for this book is the simplest one, but it shows only the lower part of the Shinao Formation. At a section (too complex for easy representation) a half kilometer north of Shinao village, fossil mammals were found; the formation was measured here and subdivided into 9 levels (in descending order):

Late Pleistocene conglomeratic sand
disconformity

9. Brownish red silty mudstone, with gravels ..... 13 m
8. Brownish calcareous conglomeratic mudstone, friable and badly layered, with a conglomerate lens 2 meters thick in the middle part..... 85 m
7. Interbedded silty mudstone with fossil mammals and gastropods..... 21 m
6. Grayish brown and bluish gray mudstone; yellow sandstone and grayish yellow thick-layered conglomerate, containing thin-layered discontinuous lignite or coaly mudstone; abundant fossil invertebrates and plants were found ..... 23 m

Source : MNHN, Paris

5. Purplish brown and blueish gray argillaceous sandstone (pinches out in the southern part of the basin)..... 34 m
4. Brownish conglomeratic silty mudstone; brontotheres, equid and gelocid mammals were discovered ..... 30 m
3. Dark gray, thick-layered conglomerate ..... 32 m
2. Brownish calcareous mudstone with gypsum veins ..... 55 m
1. Dark gray, thick-layered limey conglomerate..... 12 m

disconformity

Yellowish gray argillaceous limestone of the middle Triassic Guanling Fm.

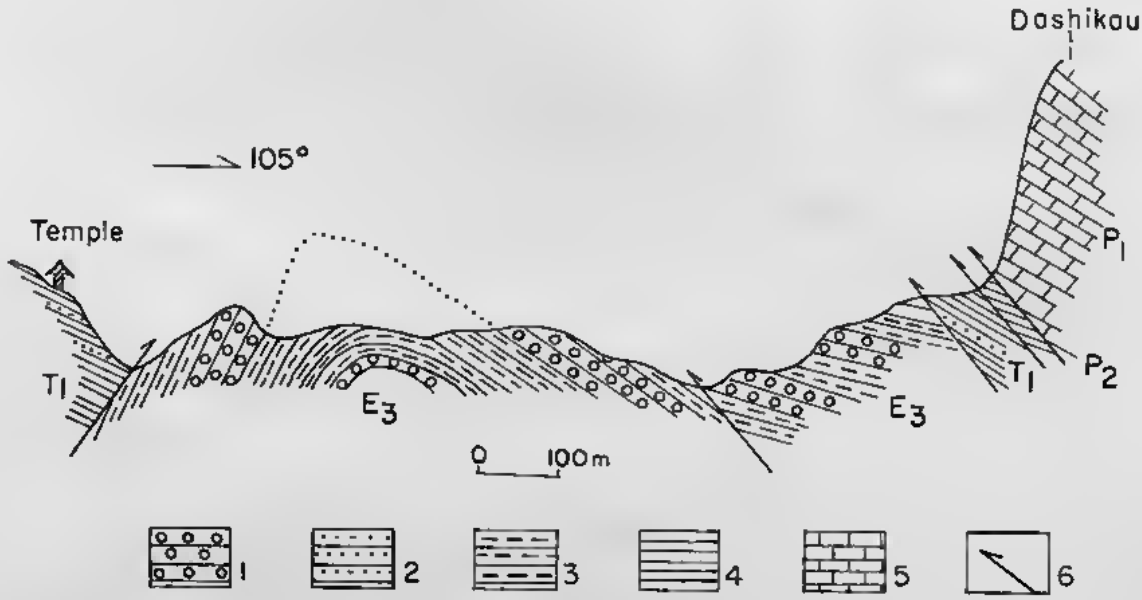


FIG. 144. — Cross section taken in the Shinao Basin, Guizhou, showing the development of the Shinao Fm. P_1. early Permian; P_2. middle Permian; T_1. early Triassic; E_3. Shinao Fm. **1.** conglomerate; **2.** sandstone; **3.** mudstone; **4** shale; **5.** limestone; **6.** fault. Modified from a figure provided by Zhai R.-j..

Level 1 does not represent the bottom of the Shinao Fm. which crops out farther north. The thickness of the Shinao Fm. varies from 500-600 m; at the section described above, it is 424 m.

The perissodactyls of the Shinao assemblage are probably neither earlier than late Eocene nor later than the early Oligocene. Until now, no pre-Oligocene *Lophiomeryx* has been cited. For these reasons, Miao (1982) concludes that the faunule is probably early Oligocene in age, although he does not exclude entirely the possibility of its being late Eocene.

Fauna of the Shinao Fm.

RODENTIA? Indet.; cited by Miao, 1982

PERISSODACTYLA

BRONTOTHERIIDAE — *Pygmaetitan panxianensis* Miao, 1982

EQUIDAE — *Qianohippus magicus* Miao, 1982

HYRACODONTIDAE Indet.; cited by Miao, 1982

ARTIODACTYLA

GELOCIDAE — *Lophiomeryx shinaoensis* Miao, 1982

— *Lophiomeryx gracilis* Miao, 1982

— *Lophiomeryx gracilis*?; cited by Miao, 1982

Source : MNHN, Paris

Lat. 43° 30′ N, approx.
Long. 112° 15′ E, approx.

Fig. 2, n° 4

CHINA

NEI MONGOL AUTONOMOUS REGION

(Inner Mongolia)

Sunid Zuoqi

Houldjin Fm. **Oligocene**

Capping the highland of a vast area and forming the surface of the Gobi in the Erenhot District is a unit that has been called the Houldjin Formation[11]. It has been described as a thin series of fluviatile deposits consisting of yellow pebbly gravels, coarse-grained sandstones and sands, crossbedded locally. The thickness of the formation reportedly varies from a few meters to a dozen meters. The Baron Sog Formation, exposed in the Nom Khong Shireh, the East Mesa and the West Mesa, is considered to be its southwestern extension, and in these three areas it is underlain by the Ulan Gochu or Urtyn Obo Formations. In the Arshanto-Irdin Manha Mesa (an unofficial name) and the east escarpment of the Fuhoborho[12] highland, the Houldjin Formation can be very similar to the underlying white sandstone of the Irdin Manha Formation.

Dating of the formation is not well resolved. Some of the forms regarded as from its sediments could be Eocene: *Hyotitan thomsoni* was described by Granger and Gregory as being more similar to Irdin Manha brontotheres than to later ones, and *Metatitan relictis* was noted to be surprisingly primitive for a supposedly late form (but it also occurs at Ergilin-Dzo). Others, whose stratigraphic position is uncertain, could also be Eocene: *Protitan*? *cingulatus, Deperetella sp., and Teleolophus* sp. And the material referred to *Indricotherium* sp., *Caenopus*? sp. and *Cadurcodon* sp. is uncertainly identified. *Hypercoryphodon*, according to McKenna (pers. com., 1985) could be from the Irdin Manha Formation just as easily as from a younger level. *Entelodon*, however, is typical of the Oligocene. Some reservation concerning its signification here is permitted since Matthew and Granger (1923a) stated in their description that "the reference to *Entelodon* is in a broad sence..." Furthermore, the single tooth on which the identification is based appears to be quite rolled and lacking in enamel details.

The lithostratigraphic evidence is perhaps not entirely conclusive as regards the reality of a Houldjin Formation and the evolutionary indications furnished by its supposed fauna concerning its age are not much more decisive. The possibility that some of the fossils might have been collected from the sediments of the Irdin Manha Formation has already been evoked by Radinsky (1965, p. 220). It is known that the lithologic characters of the Houldjin Formation can be very similar to those of the underlying(?) formation.

The distinctness of the Baron Sog Formation from the Houldjin Formation seems better substantiated, although Wall (1980) has remarked that the Houldjin beds can be correlated approximately with the Baron Sog on the basis of a large metamynodont, "possibly *Zaisanamynodon*", which occurs in both deposits.

tt It is of possible interest that the exact emplacement of the type section is presently unknown. The locality name is not known to the local natives.
Houldjin = precaution, from: to keep one's distance from an animat at the moment of its capture.
12 Fuhoborho (= Huhebolhe = Camp Margells area of the American Museum expeditions).

Source : MNHN, Paris

Fauna of the Houldjin Formation

(*: Houldjin; **: Camp Margetts)

PANTODONTA

Coryphodontidae

* — *Hypercoryphodon thomsoni* Osborn & Granger, 1932

PERISSODACTYLA

Brontotheriidae

*? — *Protitan? cingulatus* Granger & Gregory, 1943; stratigraphic position uncertain

** — *Metatitan relictus* Granger & Gregory, 1943

** — *Hyotitan thomsoni* Granger & Gregory, 1943

Deperetellidae

** — *Deperetella* sp.; cited by Radinsky, 1965; stratigraphic position uncertain

** — *Teleolophus* sp.; cited by Radinsky, 1965; stratigraphic position uncertain

Hyracodontidae

* — *Indricotherium*? sp., *in* Gromova, 1959
(= *Baluchitherium*? sp.; cited by Matthew & Granger, 1923a)

* — *Caenopus*? sp.[13]; cited by Matthew & Granger, 1923a

Amynodontidae

* — *Cadurcodon* sp., *in* Kretzoi, 1942
(= *Cadurcotherium* sp.; cited by Matthew & Granger, 1923a)

ARTIODACTYLA

Entelodontidae

* — *Entelodon dirus* Matthew & Granger, 1923a

Lat. 42°30′, approx.
Long. 111°, approx.

Fig. 2, n° 2

CHINA

Nei Mongol Autonomous Region

(Inner Mongolia)

Baron Sog Fm. **early Oligocene**

Localities: Baron Sog area, Urtyn Obo, Nom Khong Shireh

The Baron Sog Formation is typically exposed in the eastern edge of the Baron Sog[14] Mesa, a promontory in the southern part of the Shara Murun region. The formation consists of light gray clays and fine crossbedded sands. Some beds contain white marly concretions. These gray beds (also called the "upper white stratum") thin out westward and disappear, but extend far to the east and south. The greatest measured thickness was 27 feet, but it could be thicker to the east and south. The Baron Sog Formation overlies, by a distinct. smooth contact, the red clays of the Ulan Gochu Formation and is overlain by the gravels of the Gobi upland.

Very few fossils have been described from this formation, and only the *Embolotherium* comes from near the Baron Sog Lamasery; Radinsky (1964b) cites a collection of Oligocene mammals that was made in 1925, 4 to 8 miles north of the lamasery. At Urtyn Obo the highest stratigraphic unit, composed of gray and orange sands and

13 Matthew & Granger (1923a) noted that this form might as easily represent *Praeaceratherium*; Radinsky (1966) synonymized this genus with *Allacerops*, which, for Brunet (1979), should be called *Eggysodon*.

14 Baron Sog = western? doe?

Source : MNHN, Paris

gravels, was correlated with the Baron Sog beds. A section similar to that at Urtyn Obo was described at Nom Khong Shireh.

While some difficulty is encountered in correlating possible lateral extensions of the Baron Sog Formation, there appears to be no doubt concerning the reality of such a unit. If the beds that furnished *Schizotherium avitum* at Urtyn Obo are indeed referable to the formation, an early Oligocene age is indicated for it.

Fauna of the Baron Sog Formation

PERISSODACTYLA

BRONTOTHERIIDAE — *Embolotherium ultimum* Granger & Gregory, 1943

CHALICOTHERIIDAE — *Schizotherium avitum* Matthew & Granger, 1923b; cited by Coombs, 1978, from Urtyn Obo.

— *Schizotherium* sp.; cited by Coombs, 1978, from Nom Khong Shireh

Lat. 42° 30′ N, approx.
Long. 111° 30′ E, approx.

Fig. 2, n° 2

CHINA

NEI MONGOL AUTONOMOUS REGION
(Inner Mongolia)

Ulan Gochu Fm. **early Oligocene**

Locality: Ulan Gochu

American Museum parties collected fossil mammals in 1925 in the Ulan Gochu[15] Fm., on the slopes of Baron Sog Mesa (= West Mesa), but neither the Sino-Soviet expedition of 1959 nor the IVPP has added to the known material from this formation. Fossils were mainly found at East Mesa (Twin Oboes and Jhama[16] Obo), and also a few were collected at Baron Sog Mesa. Ulan Gochu is now called Bayan Obo. The Ulan Gochu Formation (with its type section at Baron Sog Mesa) is essentially a red clay attaining a maximum thickness of 17 m; it is overlain unconformably by the Oligocene Baron Sog Formation and underlain conformably by the late Eocene Shara Murun Formation.

Li and Ting (1983) combined the fossil assemblages from the Ulan Gochu and Urtyn Obo Formations, apparently considering them as equivalent. But, as pointed out by Radinsky (1964b), lithologic correlation of the beds exposed at East Mesa (Jhama Obo and Twin Oboes), Urtyn Obo and Nomogen with the type Shara Murun and Ulan Gochu strata at Baron Sog Mesa is extremely difficult. Their composition is too variable to allow correlation on the basis of lithology alone. Subsequent workers have also cited the Ulan Gochu problem (for example, Szalay & Gould, 1966; Dawson, 1968; Coombs, 1978). Dawson (1968), however, cites the occurrence in supposed Ulan Gochu deposits at both Jhama Obo and Twin Oboes of *Desmatolagus vetustus*, *Gobiolagus andrewsi*, *Anagale gobiensis*, and a small unidentified rodent as evidence that the beds referred to the Ulan Gochu Fm, at least at these two localities are contemporary.

As regards the homogeneity of the Ulan Gochu assemblage, Granger in his field notes (in Radinsky, 1964b) cautioned that the Shara Murun and Ulan Gochu beds were distinguished on faunal differences only, and confusion in field

15 Ulan Gochu = red bed (biller or sally) water.
16 Jhama Obo = Obo (cairn) of the road.

Source : MNHN, Paris

records is known to have occurred. Another feature that adds to the uncertainty of the nature of the Ulan Gochu fauna is the fact that the collections supposedly found in that level have not been completely described. Wall (1980) remarked that the Ulan Gochu Fm. contains the greatest diversity of amynodonts known in the area. This is inadequately reflected in the faunal list below. In any case, pending more detailed biostratigraphic work in the Baron Sog, East and North Mesa region, we will keep Ulan Gochu and Urtyn Obo separate (while not guaranteeing there is no mixture of faunal elements in the lists presented). But despite the stratigraphic problems envisaged above, it is probable that the Ulan Gochu and Urtyn Obo beds are lateral equivalents.

The Ulan Gochu fauna is considered early Oligocene. This is not based on a firm correlation by various faunal elements, but rather on their stage of evolution. The brontotheres, for example, are thought to be endemic forms descended from those of the Shara Murun assemblages. The Ergilin-Dzo (Ardyn-Obo) fauna can be regarded as contemporaneous, with a significant number of brontotheres and amynodonts (for the latter, see Wall, 1980) appearing in common. *Ardynomys*, or a form apparently quite similar (according to Wood (1970), but comparison of the lower dentition and skull is not possible), is known from the early Oligocene of Montana and Texas, as well as from the Ergilin-Dzo and Ulan Gochu Formations. It seems to be restricted to this age as it is only questionably present in middle Oligocene beds (in the Mynes-ke-Suyek area). Also, *Ardynomys* is considered to have given rise to the middle Oligocene genera *Cyclomylus* and *Tsaganomys*. Nothing else in the Ulan Gochu fauna is particularly indicative of its age.

Fauna of the Ulan Gochu Fm.

LAGOMORPHA

LEPORIDAE
— *Gobiolagus andrewsi* Burke, 1941 (Twin Oboes, Jhama Obo)

OCHOTONIDAE
— *Procaprolagus vetustus* (Burke, 1941) Gureyev, 1960
(= *Desmatolagus vetustus* Burke, 1941) (Twin Oboes, Jhama Obo)
(= *Desmatolagus gobiensis* Matthew & Granger, 1923d, *in* Sych, 1975, but *vetustus* is considered valid by de Muizon, 1977)

RODENTIA

PARAMYIDAE
— *Hulgana ertnia* Dawson, 1968 (Jhama Obo)
— Ischyromyidae indet; cited by Dawson, 1968 (Jhama Obo)

CYLINDRODONTIDAE
— *Ardynomys* sp.; cited by Dawson, 1968 (Jhama Obo)

ANAGALIDA

ANAGALIDAE
— *Anagale gobiensis* Simpson, 1931 (Jhama Obo, Twin Oboes)

CONDYLARTHRA

MESONYCHIDAE
— *Mongolestes hadrodens* Szalay & Gould, 1966 (Twin Oboes, Jhama Obo)

PERISSODACTYLA

BRONTOTHERIIDAE
— *Metatitan primus* Granger & Gregory, 1943 (Chimney Butte (Ulan Gochu?), *in* Granger & Gregory, 1943)
— *Metatitan progressus* Granger & Gregory, 1943 (Jhama Obo)
— *Embolotherium andrewsi* Osborn, 1929 (East Mesa)
— *Embolotherium loucksii* Osborn, 1929 (Baron Sog Mesa)
— *Embolotherium*? *grangeri* (Osborn, 1929) Granger & Gregory, 1943) (East Mesa)
(= *Embolotherium grangeri* Osborn, 1929)

AMYNODONTIDAE
— *Amynodontopsis*; cited by Wall, 1980
— *Cadurcodon*; cited by Wall, 1980
— *Zaisanamynodon*?; cited by Wall, 1980
— "several undescribed metamynodonts", cited by Wall, 1980

Source : MNHN, Paris

Lat. 42° 30′ N, approx.
Long. 111° 30′ E, approx.

Fig. 2, n° 3

CHINA

Nei Mongol Autonomous Region
(Inner Mongolia)

Urtyn Obo Fm. **early Oligocene**

Locality: Urtyn Obo

Collections were made in the Urtyn Obo[17] area by the American Museum parties in 1928 and by the Sino-Soviet expedition of 1959, but the complexity of the stratigraphy there was not recognized and the latter collection was combined as for a single fauna. Further investigation was made by IVPP crews from 1975 to 1978 and again in 1980, with the result that the sequence was clarified and many more fossils collected. The main locality is about 25 km northeast of East Mesa.

The top of the Urtyn Obo section is the Baron

Radinsky (1964)		American Museum denominations	Present denominations
10m	gray and orange sands and gravels "Upper White"	correlated with Baron Sog beds	Upper Naugandai Fm.
32m 40m	brick red silts "Upper Red"	referred to Ulan Gochu beds, but not present at East Mesa	lower Naugandai Fm. or upper Urtyn Oba Fm.
10m 13m	light colored sands and gravels "Middle Gray, or White"		
20m 23m.	brick red silts "Middle Red"	equivalent to the single red unit assigned to Ulan Gochu beds at East Mesa	lower Urtyn Obo Fm.
22m	cancretionary layer near top gray sands	Ulan Gochu beds ?__boundary not determined	
17m	pink silts "Lower Red"	Shara Murun beds	Ali Usu Fm. = Irdin Manha Fm.
?m	gray silts "Basal Gray, or White"	Shara Murun beds	
?m	bright red silts "Basal Red"	a possible correlate of the Ulan Shireh or Tukhum beds	Arshanto Fm.

Fig. 145. — Chart showing nomenclature equivalents based on the section at Urtyn Obo (from Radinsky, 1964b); American Museum Expedition field designations are in quotes. Zhai considers it doubtful that the Shara Murun beds are present at Urtyn Obo

17 Urtyn Obo (= Erden Obo) = obo of the people (the herdsmen).

Source : MNHN, Paris

Sog Formation, but this, and the bed immediately underneath, have been termed the Naugondai Formation by Nei Mongol geologists. The lower part of the Naugondai Formation is thought by the IVPP to constitute in reality the upper part of the Urtyn Obo Formation (which otherwise underlies the Naugondai Formation). Although a fairly large collection was made in the classic Urtyn Obo Formation, the lower Naugondai Formation is even richer.

The restricted Urtyn Obo Formation constitutes the "lower gray" and the "middle red" beds of the American Museum (see Radinsky, 1964b), while the lower Naugondai Formation comprises the " middle white" and the "upper red" beds. We will consider the early Oligocene Urtyn Obo fauna to include these four levels. The latter sediments are underlain by the Irdin Manha Formation (= "lower red" and "basal gray" of the American Museum), with the Arshanto Formation (= "basal red") at the bottom of the section. As mentioned above, the top is crowned with the Baron Sog Fm., or the upper part of the Nongaudai Formation.

Present opinion in China, which considers the Shara Murun beds to be absent at Urtyn Obo, confirms the suspicions of Radinsky (1964b, 1965) when he was confronted with several specimens that seemed not to fit in an Oligocene assemblage. The type (and only) specimen of *Teleolophus magnus* was one of these; AMNH n° 26138, called *Schlosseria*? sp., and *Lophialetes* sp. (AMNH 26138) are others. They are here referred to the Irdin Manha Formation.

A preliminary faunal list for the upper Urtyn Obo Formation (or lower Naugondai Formation) includes elements that indicate an early Oligocene age. Of particular interest is an undescribed maxillary (with P1-M3) that might represent the upper dentition of *Urtinotherium*, which could solve several taxonomic problems; the type lower jaw also comes from this level. In the lower Urtyn Obo level was found the already described material of *Entelodon*, *Amynodon alxaensis* and mesonychids.

While it is necessary to await complete description of this fauna an early Oligocene age for it can already be deduced.

Fauna of the Urtyn Obo Fm. (at Urtyn Obo)

LAGOMORPHA

LEPORIDAE — *Gobiolagus? major* Burke, 1941

CONDYLARTHRA

MESONYCHIDAE Indet.; cited by Zhai, pers. com., 1980

PERISSODACTYLA

BRONTOTHERIIDAE — *Parabrontops gobiensis* (Osborn, 1925) Granger & Gregory, 1943 (= *Brontops gobiensis* Osborn, 1925)

CHALICOTHERIIDAE — *Schizotherium* cf. *avitum* Matthew & Granger, 1923b; cited by Coombs, 1978

HYRACODONTIDAE — *Ardynia praecox* Matthew & Granger, 1923; cited by Radinsky, 1967

— *Urtinotherium incisivum* Chow & Chiu, 1963, V.P. (3)

AMYNODONTIDAE — *Cadurcodon ardynensis* (Osborn, 1923c) Kretzoi, 1942; cited by Xu, 1966, V.P. (2)
(= *Cadurcotherium ardynense* Osborn, 1923c)

— *Cadurcodon* sp.; cited by Xu, 1966, V.P. (2)

— *Amynodontopsis parvidens* Wall, in press

— *Amynodon alxaensis* Qi, 1975, V.P. (4); cited by Zhai, pers. com., 1980

ARTIODACTYLA

ENTELODONTIDAE — *Entelodon* sp., *in* Brunet, 1979
(= *Archaeotherium ordosius* Young & Chow, 1956; cited by Hu, 1964, V.P. (3))

Source : MNHN, Paris

Lat. 39° 40′ N, approx.
Long. 104° 45′ E, approx.

Fig. 2, n° 28

CHINA

Nei Mongol Autonomous Region
(Inner Mongolia)
Haosibuerdu Basin

Chaganbulage Fm. **early Oligocene**

Locality: Chaganbulage (Suhaitu)

The Haosibuerdu Basin[18] is located in the central part of Alxa Zuoqi[19]. In the 1950's and early 1960's the latter was administratively part of Inner Mongolia, but during the late 1960's and 1970's it was changed to become part of the Autonomous Region of Ningxia. In 1979 it was again placed under the governmental control of Nei Mongol.

The locality of Suhaitu was visited by the Sino-Soviet Expedition of 1959, which recovered

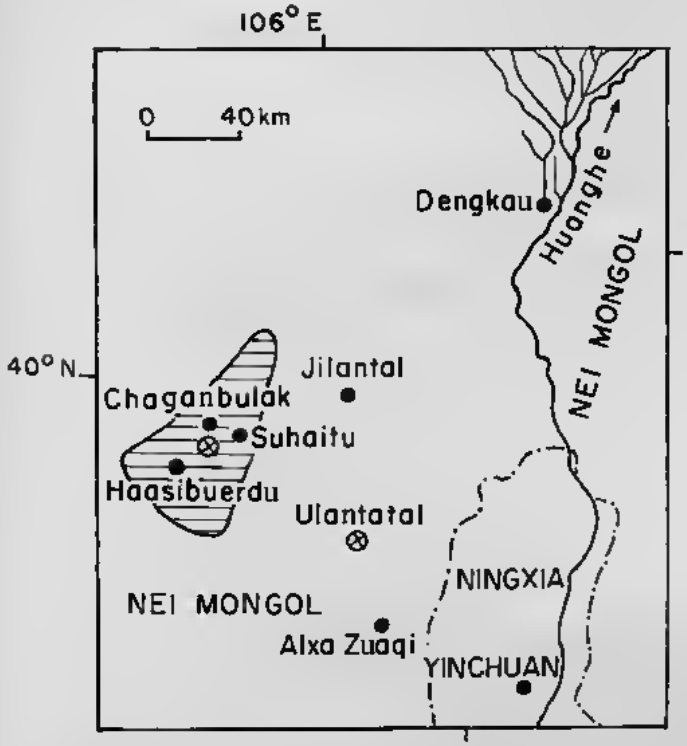


Fig. 146. Map of the Alxa Zuoqi region showing the situation of the Haosibuerdu Basin, Nei Mongol (in hachures). Modified from Jiang *et al.*, 1976.

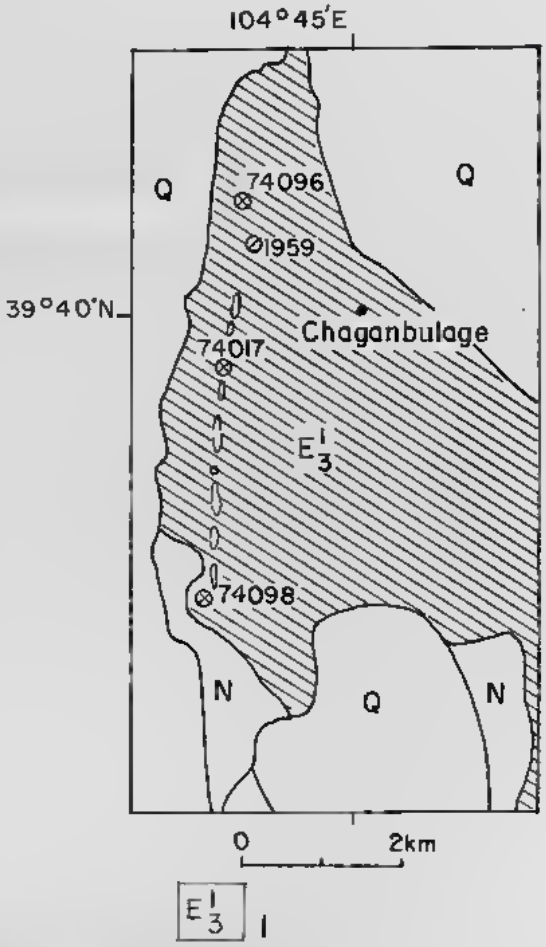


Fig. 147. — Sketch map of the Alxa Zuoqi region, Nei Mongol, showing the location and extent of the Haosibuerdu Basin. 1, outcrop of the early Oligocene Chaganbulage Fm. N = Pliocene; Q = Quaternary flood plain deposits. The locality marked 1959 was excavated in that year. Modified from Jiang *et al.*, 1976.

18 Haosibuerdu (= Housburdu = Hosburd = Suhaitu) = tamarisk.
19 Alxa Zuoqi = Left Alxa Qi (= county) = Left Alxa County (= Alashan).

Source : MNHN, Paris

fossil mammals from grayish and greenish clays in the basal part of a lenticular pocket. In 1971, Ningxia geologists mapped part of the area and in 1974 IVPP members joined the brigade and discovered more fossils in the Chaganbulage area; IVPP activity continued in 1978. The locality is about 120 km northwest of Alxa Zuoqi City.

The Chaganbulage[20] Formation is divided into three parts, with the upper part consisting of beds of gypsum near the top, situated in light brown silt and sandy mudstone; the latter can become green and contain lenses of yellow sand and gravel. The thickness of this unit is more than 40 m. The middle part is reddish and brown muddy sandstone which contains thin-layered

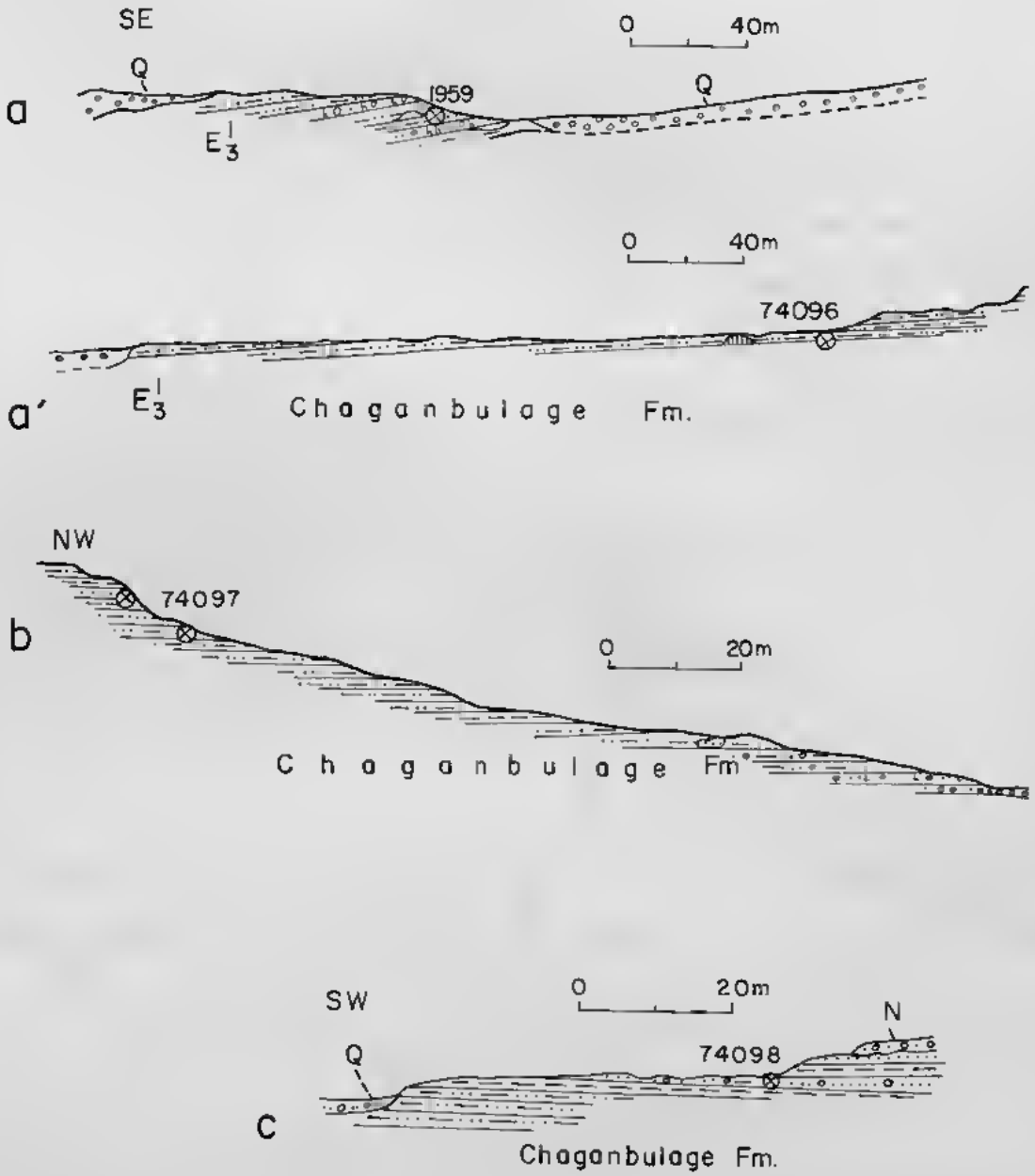


FIG. 148. — a-a', cross section taken between locality 74096 and that excavated in 1959 in the northern part of the early Oligocene outcrops of the Chaganbulage Fm. in the Haosibuerdu Basin, Nei Mongol. b, cross section taken at localities 74097 and 74098. Modified from Jiang *et al.*, 1976.

20 Chaganbulage (= Lügenzadage) = white spring.

Source : MNHN, Paris

mudstone and silt; thickness, 70 m. The bottom part is mainly gray-white or reddish gravel with brown sand, mudstone and sandstone; crossbedding occurs and the thickness is 30 m. Fossils were found in two levels, but only in the top of the formation. It is overlain by unnamed Pliocene deposits and underlain disconformably by sediments of Cretaceous age.

The fauna of the Chaganbulage Formation is not varied; its principal argument for being considered as already Oligocene lies in the presence of an *Embolotherium* similar to those of Ardyn Obo.

Fauna of the Chaganbulage Fm.

LAGOMORPHA Indet.; cited by Qi, 1975, V.P. (4)

RODENTIA Indet.; cited by Qi, 1975, V.P. (4)

CONDYLARTHRA

MESONYCHIDAE
— *Harpagolestes? alxaensis* (Qi, 1975) Qi 1981, V.P. (2)
(= *Harpagolestes alxaensis* Qi, 1975, V.P. (4))

PERISSODACTYLA

BRONTOTHERIIDAE
— *Embolotherium? grangeri* (Osborn 1929) Granger & Gregory, 1943; cited by Qi, 1975, V.P. (4)
(= *Embolotherium grangeri* Osborn, 1929; cited by Qi, 1981, V.P. (2))

DEPERETELLIDAE
— *Teleolophus* cf. *medius* Matthew & Granger, 1925f; cited by Qi, 1981, V.P. (2)
— *Teleolophus magnus*[21] Radinsky, 1965; cited by Qi, 1981, V.P. (2)

AMYNODONTIDAE
— *Paracadurcodon suhaituensis* Xu, 1966, V.P. (2); cited by Jiang *et al.*, 1976, V.P. (1)
— *Amynodon alxaensis* Qi, 1975, V.P. (4)
— *Sianodon* sp.; cited by Xu, 1966, V.P. (2)
— Amynodontidae? Indet.; cited by Qi, 1975, V.P. (4)

PERISSODACTYLA Indet.; cited by Qi, 1975, V.P. (4)

ARTIODACTYLA

ENTELODONTIDAE Indet.; cited by Chow & Rozhdestvensky, 1960, V.P. (1)
CERVIDAE Indet.; cited by Qi, 1975, V.P. (4)
BOVIDAE Indet.; cited by Jiang *et al.*, 1976, V.P. (1)

21 This identification is based on a lower jaw with well worn teeth, whose P/4 is not so molariform as that of the type *T. magnus*; *T. magnus* is otherwise considered to be referable to the Irdin Manha level.

Source : MNHN, Paris

Lat. 34° 09' N
Long. 109° 19' E
(Lantian Town)

Fig. 2, n° 9

CHINA
SHAANXI PROVINCE
(Shensi)
Lantian District

late Eocene?-early Oligocene

Bailuyuan Formation
Localities: see text

The Bailuyuan[22] Formation is the upper one of the two early Tertiary formations in the Lantian District (for more information concerning these beds, refer to the discussion under Honghe Formation). It is mainly composed of grayish white sandstone, but is divided lithologically into three parts. The upper level consists principally of coarse white sandstone with sporadic beds of chocolate colored clay containing purplish red and chocolate colored mud balls and sandy concretions; fossils have been found in the sandy concretions. The middle level is grayish white sandstone intercalated with purplish red mudstone, and the lower part is composed of thick-bedded sandstone with thin beds of purplish red mudstone. There are two fossiliferous levels; one is in the lower part, in sandy concretions within the purplish red mudstone, itself conttained in the thick white sandstone, and the other is in the upper part, also in concretions in the mudstone. A vertical distance of about 200m separates the two levels. The total thickness of the formation is 400m. It disconformably overlies the Honghe Formation and is overlain by Neogene sediments.

The fossils from the Bailuyan Formation were found at several localities:

— Gaopacun[23], in Shilihegou[24], Lantian County (loc. 64005): Palaeolaginae indet.
— Shahegou[25], near Xian (loc. 63705): *Sianodon bahoensis*
— Maoxicun[26], near Xian (loc. 63704): *Sianodon bahoensis* and *Sianodon* sp.
— Kangwangou[27], near Chenjiawucun[28], Xiehu

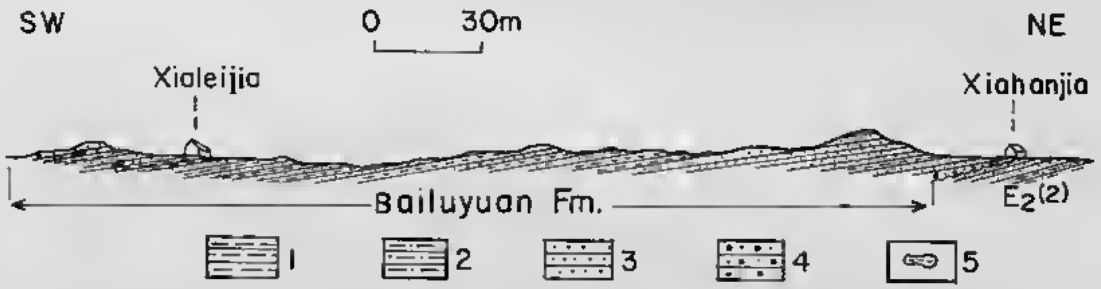


FIG. 149. Cross section taken in the region of Zhijiagou, in the Lantian District, Shaanxi, showing the Bailuyan Fm. The above section is covered by the dot indicating Shanghanjia on Fig. 55. **1.** mudstone; **2.** sandy mudstone; **3.** sandstone; **4.** conglomerate; **5.** mudstone lens. Modified from Chia *et al.*, 1966.

22 Bailuyuan = white deer platform (?) (a high place, flat on top, usually formed on loess, but not a plateau).
23 Gaopocun = slope in high place village.
24 Shilihegou = 10 li (= ½ km) river village.
25 Shahegou = sandy river valley.
26 Maoxicun = Mao (family name) west village.
27 Kangwanggou (= Kongkouwan) = Kang (family name) curved valley.
28 Chenjiawucun = Chen (family name) village.

Source : MNHN, Paris

Commune, Lantian County (loc. 64017): *Lantianius xiehuensis*
— Yinpocun[29], near Xian (loc. 65008): *Simplaletes xianensis*

With respect to the correlation of the Bailuyuan Formation, material of *Sianodon bahoensis* is quite similar to that from the Caijiachong Formation in Qujing (Yunnan) which is considered to be early Oligocene. *Simplaletes* appears to indicate an early Oligocene or late Eocene age too. It must be admitted that there is no faunal reason for supposing that a late Eocene part exists in the Bailuyuan Formation, but experience has shown that elsewhere in North China where the early Oligocene is found, there is usually an underlying component that is late Eocene. While not necessarily a critical argument, the thickness of the formation is sufficient to easily permit the hypothesis of a late Eocene age for the lower part. This is obviously a tentative arrangement.

Fauna of the Bailuyuan Formation

LAGOMORPHA
LEPORIDAE — Palaeolaginae indet.; cited by Li, 1965, V.P. (1)
PERISSODACTYLA
LOPHIALETIDAE[30] — *Simplaletes xianensis* Zhang & Qi, 1981, V.P. (3)
AMYNODONTIDAE — *Sianodon bahoensis* Xu, 1965, V.P. (1)
— *Sianodon* sp.; cited by Xu, 1966, V.P. (2)
ARTIODACTYLA
FAMILY Indet. — *Lantianius xihuensis*[31] Chow, 1964, V.P. (3)

Lat. 35° 06′ N
Long. 111° 53′ E

Fig. 2, n° 7

CHINA
SHANXI PROVINCE
Yuanqu Basin

Baishuicun Formation **early Oligocene**

For details of the stratigraphy of the Yuanqu (= Yuanchu) Basin, see the discussion under the late Eocene Heti Formation.

In 1961 a specimen of *Brachyodus* was obtained from a locality situated on the east bank of Gianhe stream near the village of Baishui[32], 7.5 km from the city of Yuanqu.

The Baishuicun[33] Formation consists of alternating beds of marl and freshwater limestone with two levels of lignite; its total thickness is 13 m. It is overlain by Quaternary deposits but its base is not visible. In fact, in so far as is known, no contact is visible between the Baishuicun Formation and the supposedly underlying Heti Formation.

The single taxon (found in the lignite), *Bra-*

29 Yinpocun = north slope village.
30 Badamgarav & Reshetov (1985) say this form is perhaps referable to the Hyracodontidae.
31 Identified as an artiodactyl by Gingerich, 1976.
32 Baishui = Paise.
33 Baishuicun (= Paisuitsin) = white river village.

Source : MNHN, Paris

chyodus hui[34] (Chow, 1958b) *in* Wang & Hu, 1963, V.P. (4), (= *Hyoboops hui* Chow, 1958b, V.P. (4)), appears to represent the same taxon identified in the Xiaotun Fm. of the Lunan Basin (Yunnan). The latter was not found in place; we do consider it, however, to be early Oligocene in age.

Lat. 53° N approx.
Long. 91 E approx.

CHINA

Xinjiang Uygur Autonomous Region

(Sinkiang)

Hami Basin

formation unknown **early Oligocene**

Locality: Yemaquan

In the spring of 1959, four brontothere molars were sent to the IVPP for identification by the Geological Bureau of Xinjiang in Urumqi[35]. Two years later Mrs Hu Chang-kang described these fossils in order to note the first fossil record of brontotheres in Xinjiang. It was said in Hu's paper that these fossils were collected in Yemaquan[36], Hami Basin, but at that time neither stratigraphical nor locality information other than the locality name was known. During the IVPP expeditions of 1964 and 1966 to Xinjiang it was found that there are several places called Yemaquan. The expedition failed to determine which one had yielded the fossils. The personnel could be certain only that Eocene-Oligocene continental sediments do crop out widely in the Hami Basin.

Hu thought that the age of the fossils was most probably early Oligocene. She was probably right as *Parabrontops* is found at the early Oligocene sites of Ardyn Obo and Urtyn Obo. We tentatively accept this designation.

Fauna of the Hami Basin

PERISSODACTYLA

Brontotheriidae — *Parabrontops* sp.; cited by Hu, 1961, V.P. (1)

34 Dineur (1982) refers this species to the genus *Bothriogenus*, and considers it close to *B. andrewsi*, from the early Oligocene of Egypt.

35 Urumqi (= Urumchi).

36 Yemaquan (= Yiemaquan).

Source : MNHN, Paris

Lat. 24° 58′ N
Long. 104° 20′ E
(Luoping City)

Fig. 2, n° 36

CHINA
YUNNAN PROVINCE
Luoping Basin

unnamed formation **early Oligocene**

A large astralagus from this small basin in eastern Yunnan was brought to the attention of Mr. Chiu (= Qiu) of the IVPP, who investigated the area in 1960. He found more material, but exposures of the fossiliferous beds (an unnamed formation) are very limited. The sediments are mainly composed of gray and yellow (and sometimes green) marly clays, with a thickness of about 10 m. Contacts with under- or overlying formations were not evident.

Indricotherium intermedium[37], from these deposits represents an evolutionary stage about intermediate between the supposedly late Eocene (Lumeiyi Formation) *I. parvum* and the middle Oligocene *I. transouralicum*. On this basis the beds may be considered as early Oligocene or, less probably, early in the middle Oligocene.

Fauna of the Luoping Basin

PERISSODACTYLA
HYRACODONTIDAE — *Indricotherium intermedium* Chiu, 1962, V.P. (1)

Lat. 24° 47′ N
Long. 103° 16′ E
(Lunan Town)

Fig. 2, n° 25

CHINA
YUNNAN PROVINCE
Lunan Basin

Xiaotun Fm. **early Oligocene**

The history of the development of stratigraphical considerations in this basin is related under the late Eocene Lumeiyi Formation.

The Xiaotun[38] Formation crops out in the western part of the basin. Its lower part consists of gray and brown argillaceous sandstone which locally contains gravels. The upper part is of brownish red argillaceous sandstone and sandy clay and toward the top the sandstone becomes dominant. Total thickness of the formation is 40-

37 *Indricotherium intermedium* Chiu, 1962, V.P. (1) is based on an upper molar (and some fool bones); *Urtinotherium incistrum* Chow & Chiu, 1963, V.P. (3) is based on a lower jaw and the two may be synonymous. But according to Radinsky, 1967, *Indricotherium parvum* Chow, 1958, V.P. (4) might also represent the same taxon as *Urtinotherium incisivum*, in which case it would have precedence over both of the above names.

38 Xiaotun = small village.

Source : MNHN, Paris

50m. Fossils occur onlu in its upper part. The formation isunderlain by the Lumeiyi Formation and covered by Quaternary deposits.

In the fossil list cited below, the hyracodontid and the artiodactyl are not yet described. All three taxa were collected by the 1970 IVPP expedition.

Correlation with the larger fauna of the Caijiachong Fm. is indicated by the presence of a form close to *Gigantamynodon giganteus*. *Bothriogenus* is known from the early Oligocene of the Fayum (Egypt) and could support a similar age for the Xiaotun Fm.

Fauna of the Xiaotun Fm.

PERISSODACTYLA

HYRACODONTIDAE Indet.; cited by Zhang *et al.*, 1978

AMYNODONTIDAE — cf. *Gigantamynodon giganteus* Xu, 1961, V.P. (4); cited by Zheng *et al.*, 1978

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Bothriogenus hui*[39] (Chow, 1958b) Dineur, 1982
(= *Hyoboops hui* Chow, 1958b, V.P. (4))
(= *Brachyodus hui* (Chow, 1958b), Xu, 1962, V.P. (3))
(= *Bothriodon* sp.; cited by Chow 1958b, V.P. (4), *in* Xu, 1962, V.P. (3))

ARTIODACTYLA Indet.; cited by Zheng *et al.*, 1978

Lat. 25° 30′ N, approx.
Long. 104° E, approx.

Fig. 2, n° 24

CHINA
YUNNAN PROVINCE
Yuezhow Basin

Caijiachong Fm. **early Oligocene**

The Caijiachong[40] area is situated in Qujing[41] County in the northwest part of the Yuezhow Basin. The first mammalian material known from here was a tooth described by Young in 1932, which was the first definite record of Tertiary mammals in South China. More material was collected by Bien in the years preceding 1940 and the IVPP sent expeditions there in 1960, 1972 and 1980.

The stratigraphic sequence consists of early Tertiary sediments overlying unconformably a Permian limestone to the east and Carboniferous limestone to the west. Bien and Young (1939) and Bien (1940) divided the Tertiary deposits into two parts: the lower Caijiachong subaerial sandstone overlain by an upper Caijiachong lacustrine unit. The field work carried out by the IVPP in 1980 resulted in a division of these sediments into two formations, the Caijiachong Formation consisting of the lacustrine beds and, separated by an unconformity, the underlying Gelanghe Formation. The total thickness is 218m.

The top layer of the Caijiachong Formation consists of grayish green marls, calcareous mudstone intercalated with mudstone and siltstone; it

39 The type material of this species was not found in place, but it is thought to be of early Oligocene age.
40 Caijiachong (= Tsaichiachung, = Chaijiachong *in* Zhang *et al.*, 1978) = Cai (family name) main road.
41 Qujing (= Chuehing = Chuchiang = Qijing *in* Zhang *et al.*, 1978) = place name.

Source : MNHN, Paris

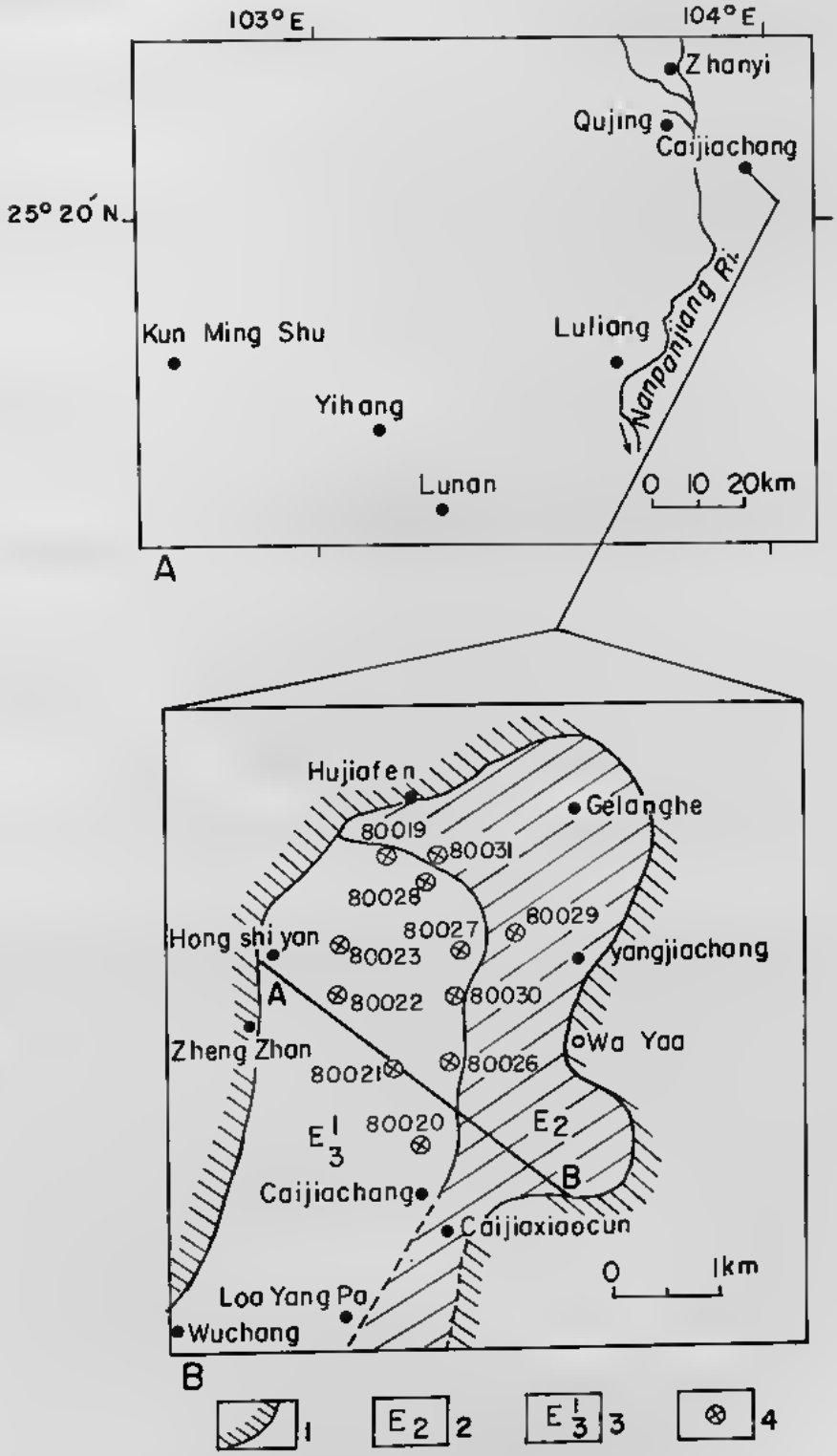


FIG. 150. — A. Sketch map showing the location of Caijiachong, Qujing county, Yunnan Province. B. Sketch map showing the distribution of the early Tertiary formations in the Caijiachong area. 1. Paleozoic; 2. Gelanghe Fm.; 3. Caijiachong Fm.; 4. fossil mammal locality. Modified from Wang and Zhang, 1983.

Source : MNHN, Paris

is rich in charophytes hand has yielded unidentified rodent, brontothere, amynodont, rhinocerotid and artiodactyl material, along with *Cadurcodon, Gigantamynodon, Entelodon* and *Bothriodon.*

The middle layer is composed of light gray marls intercalated with varicolored mudstone and silstone; it is also rich in charophyres and has produced unidentified erinaceids, brontotheres, amynodonts, lagomorphs and carnivores, as well as *Parasminthus, Eucricetodon, Karakoromus, Prohyracodon, Miomeryx, Lophiomeryx,* and cf. *Indomeryx.*

The bottom layer is essentially gray mudstone, in which were found unidentified brontotheres, *Prohyracodon, Cadurcodon,* and cf. *Indomeryx.*

The Gelanghe Fm. consists of red beds with siltstone, sandstone and a basal breccia. No fossils were known from it until 1980, when unidentified rodent and primate(?) material was

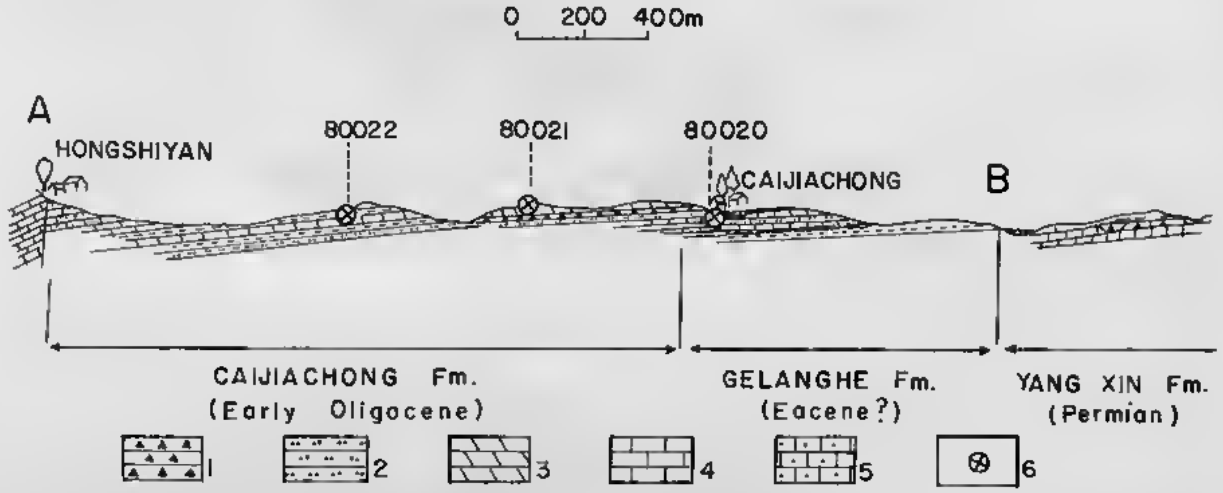


FIG. 151. — Section of the early Tertiary in the Caijiachong area, Qujing County, Yunnan Province. **1.** breccia; **2.** siltstone or mudstone; **3.** marls; **4.** limestone; **5.** " wool stone "; **6.** fossil mammal locality. Modified from Wang and Zhang, 1983.

discovered. Its age remains uncertain, but it could well be late Eocene as originally suggested by Young & Bien (1939) and Bien (1940).

The age of the Caijiachong Formation has been frequently discussed. It was thought to be Pliocene by Young (1932), based on the first discovered specimen from these beds which was identified as *Merycopotamus.* In this he was followed with slight modification by Colbert (1940). With additional material Young & Bien (1939) and Bien (1940) determined it as Oligocene in age, which was confirmed by Chow (1957a) and Xu (1961), who considered it to be early Oligocene.

Evaluation of the faunal list of the Caijiachong Formation gives mixed results. While it is true that the artiodactyl element is very similar to that known at Ardyn-Obo (early Oligocene of Ergilin-Dzo), the rodents strongly suggest Shand-Gol (middle Oligocene) affinities. The species of *Cadurcodon* is the same as that found at Ardyn-Obo and although *Gigantamynodon gigantea* is bigger than the species from the latter locality, its characters are similar. Also, the principal characters of *Bothriodon chowi* resemble those of *B. velaunus* from Ronzon in France. We will retain the Caijiachong Formation in the early Oligocene, while looking forward to future discoveries and an explanation of the rodents in the fauna.

Fauna of the Caijiachong Formation

INSECTIVORA

ERINACEIDEA Indet.; cited by Rich *et al.*, 1983
DORMAALIIDAE Indet.; cited by Rich *et al.*, 1983

Source : MNHN, Paris

CHIROPTERA

VESPERTILIONOIDEA Indet.; cited by Rich *et al.*, 1983

PRIMATES? Indet.; opinion of the authors

LAGOMORPHA Indet.; cited by Wang & Zhang, 1983, V.P. (2)

RODENTIA

CRICETIDAE
— *Eucricetodon* sp.; cited by Wang & Zhang, 1983, V.P. (2)

CTENODACTYLIDAE
— *Karakoromys* sp.; cited by Wang & Zhang, 1983, V.P. (2)
— *Dianomys obscuratus* Wang, 1984[42]
— *Dianomys qujingensis* Wang, 1984

DIPODIDAE
— *Parasminthus* sp.
(= *Plesiosminthus* sp.; cited by Wang & Zhang, 1983, V.P. (2))

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Zhang *et al.*, 1978; presumably other material is cited by Wang & Zhang, 1983, V.P. (2)

HYRACODONTIDAE
— *Indricotherium intermedium* Chiu, 1962, V.P. (1)
— *Indricotherium qujingensis* Tang, 1978b
(= *Indricotherium chuchingensis, in* Zhang *et al.*, 1978)
— *Indricotherium* sp.; cited by Xu, 1961, V.P. (4)
— *Prohyracodon* sp.; cited by Wang & Zhang, 1983, V.P. (2)
— Caenopinae indet.; cited by Xu, 1961, V.P. (4)

RHINOCEROTIDAE Indet.; cited by Wang & Zhang, 1983, V.P. (2)

AMYNODONTIDAE
— *Gigantamynodon giganteus* Xu, 1961, V.P. (4)
— *Gigantamynodon* cf. *giganteus* Xu, 1961; cited by Zhang *et al.*, 1978
— *Gigantamynodon* sp.; cited by Zhang *et al.*, 1978
— *Cadurcodon ardynensis* (Osborn, 1923c) Kretzoi, 1942; cited by Xu, 1961, V.P. (4)
(= *Cadurcotherium ardynense* Osborn, 1923c)
— *Cadurcodon* sp.; cited by Xu, 1961, V.P. (4)
— cf. *Metamynodon* sp.; cited by Xu, 1961, V.P. (4)

ARTIODACTYLA

ENTELODONTIDAE
— *Entelodon* sp.; cited by Wang & Zhang, 1983, V.P. (2)

ANTHRACOTHERIIDAE
— *Bothriodon chowi* Xu, 1961, V.P. (4)
(= *Bothriodon* sp.; cited by Chow, 1957a, V.P. (3)
(= *Merycopotamus* sp.; cited by Young, 1932)

LEPTOMERYCIDAE
— *Miomeryx* sp; cited by Wang & Zhang, 1983 V.P. (2)
(=? cf. *Miomeryx* sp.; cited by Xu, 1961, V.P. (4))

GELOCIDAE
— cf. *Indomeryx* sp.; cited by Wang & Zhang, 1983, V.P. (2)
— *Lophiomeryx* sp.; cited by Wang & Zhang, 1983, V.P. (2)

ARTIODACTYLA Indet.; cited by Wang & Zhang, 1983, V.P. (2)

42 Cited as Yuomyidae; see footnote n° 11, p. 77.

Source : MNHN, Paris

Lat. 43° N, approx.
Long. 145° E, approx.

Fig. 129, n° 5

JAPAN

HOKKAIDO

Hokkaido Prefecture

Ten-neru Fm **early Oligocene?**

Locality: Kushiro-cho

In 1968 the latest of the rare Paleogene mammalian fossils of Japan was discovered in the area of Kushiro, eastern Hokkaido. The specimen was kept, but unstudied, in the Kushiro City Museum until 1982 when it was brought to the attention of Dr. Y. Tomida, who published its descriprion in 1983.

The specimen, a palate of a helaletid perissodactyl, was found about half way up the sea cliff facing the Todo Iwa[43], about 5 ½ km east of the village of Konbumori, itself about 10 km east of Kushiro City.

The fossil-bearing bed is a fine sandstone near the middle of the Ten-neru Formation. The latter consists mainly of characteristic reddish brown pebble-sized conglomerates, with minor proportions of sandstone and mudstone. The thickness of the formation in this area is approximately 90 m. It forms part of the Urahoro Group, a series of mainly freshwater sediments that is divided into 7 formations and is well known for its rich coal deposits. The Ten-neru Formation is conformably (?) overlain by the Yubetsu Formation and conformably (?) underlain by the Harutori Formation.

The age of the Urahoro Group is considered as Eocene-Oligocene based on studies of plants, mollusks and Foraminifera; an early to middle Oligocene age was obtained by the mollusks, late Eocene (Priabonian) by Foraminifera, and early to middle Oligocene by the succession of fossil floras. These correlations are admitted to be somewhat insecure. The mammalian species from the Ten-neru Formation most resembles *Colodon*? *hancocki* from the Clarno Formation of western North America. This formation is considered to be late Duchesnean or early Chadronian, which is probably the equivalent of earliest Oligocene. Tomida suggests, from its stage of evolution, that the Japanese form might be slightly younger than *Colodon*? *hancocki*, or Chadronian.

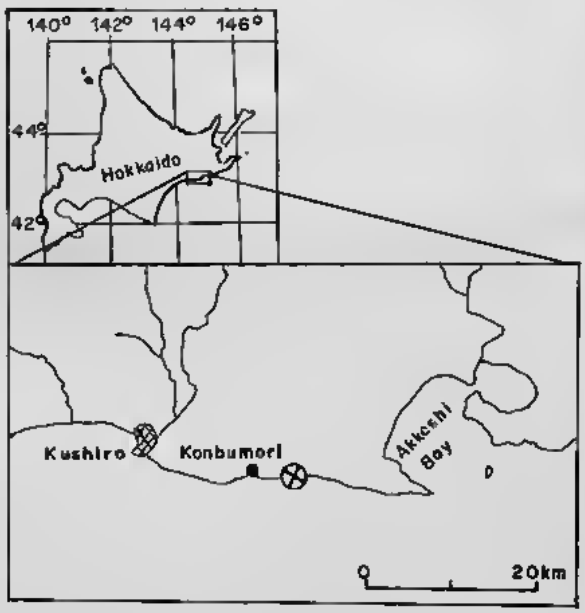


FIG. 152. — Sketch map showing the geographic situation of the fossil mammal locality near Kushiro, Hokkaido, Japan. Modified from Tomida, 1983.

Fauna of the Ten-neru Fm. at Kushiro

PERISSODACTYLA

HELALETIDAE — *Colodon? kushiroensis* Tomida, 1983

43 Todo Iwa = sea lion rock.

Source : MNHN, Paris

Lat. 37° N
Long. 140° 50′ E

Fig. 129, n° 3

JAPAN

HONSHU

Fukushima Prefecture

Iwaki Fm. **Oligocene**

Locality: Joban coal field

In 1957 an isolated mammalian upper molar was found in a coarse-grained sandstone in the Iwaki coal-bearing formation, in the Joban coal field along the eastern foot of the Abukuma Mountains. The fossil was discovered 454 m below sea level, at 14 m above the upper coal

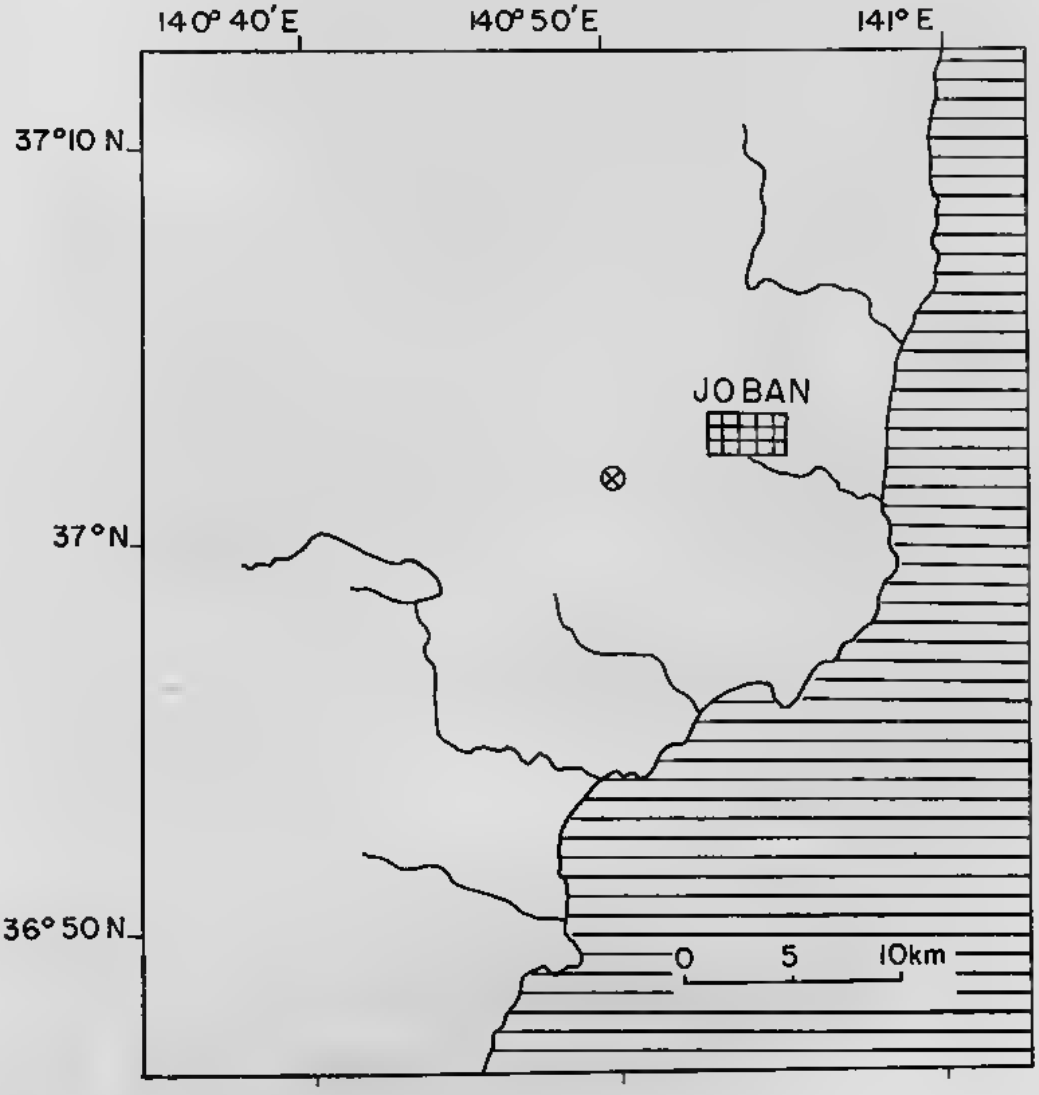


FIG. 153. — Map showing the situation of the fossil mammal locality of Joban, Honshu, Japan. Modified from a map provided by Y. Tomida.

Source : MNHN, Paris

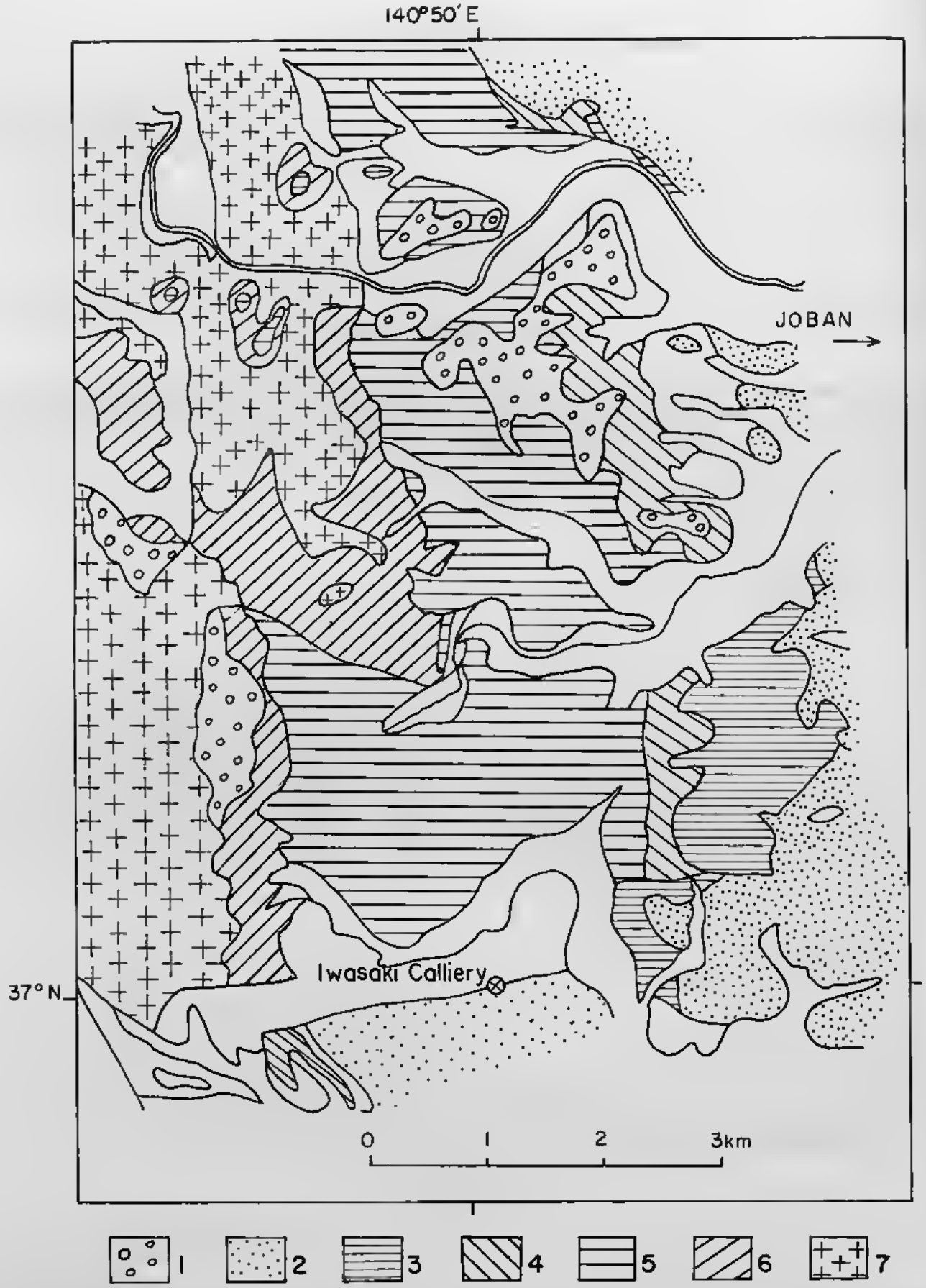


FIG. 154. — Detailed geological map showing the fossil mammal locality at the Iwasaki Colliery of the Joban Coal Mine Company, near Joban, Honshu, Japan. **1**. terrace deposits; **2**. Yunagaya Group; **3**. Shirasaka Fm.; **4**. Asagai Fm.; **5**. Iwaki Fm.; **6**. Shiramizu Fm.; **7**. intrusive rocks. Modified from Hatai and Kamada, 1950.

Source : MNHN, Paris

seam, and 255 m from the entrance to the south incline of the Iwasaki Colliery, Joban Coal Mine Company.

The tooth was "provisionally" given the specific name of *tsuchiyai* (after its discoverer, Mr. Sukeji Tsuchiya) by Takai in 1961 and tentatively referred to the anthracothere *Anthracothema*. Tomida (pers. com., 1984) has reidentified the specimen as *Entelodon* sp.

The Iwaki Formation is made up of shallow marine deposits consisting of sandstones and conglomerates, 50 to 300 m in thickness; coal seams sometimes occur. Formational names in the area have varied over the years.

In a detailed study Hatai and Kamada (1950) stated the beds in question belonged to the Uchigo Group, within which the Iwaki Formation was said to conformably overlie the Shiramizu Formation, of terrestrial or brackish water origin, and to lie unconformably on granite or Paleozoic rocks. The Asagai Formation conformably overlies the Iwaki and is composed of fine sandstone laid down by a marine transgression. This sequence of names is followed by Saito (1972), but Asano (1963) places the Iwaki at the bottom of a series that unconformably rests on the Cretaceous Futaba Group.

The age of the Iwaki Formation has usually been considered as early middle Oligocene, based on invertebrate and paleobotanical evidence. Until Tomida's new identification of the mammalian specimen, the latter was thought to represent the Late Eocene; Tomida now suggests that the mammalian element also implies an Oligocene age supporting the evidence from other disciplines.

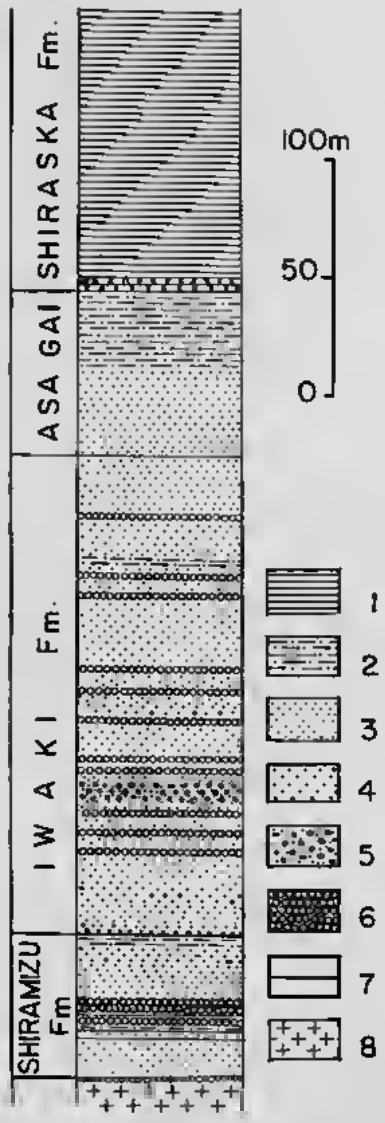


FIG. 155. — Stratigraphic section taken in the Yumoto area, near Joban, Honshu, Japan; the Iwasaki Colliery of the Joban Coal Mine Company lies within this area. 1. shale; 2. sandy shale; 3. sandstone; 4. coarse sandstone; 5. conglomeratic sandstone; 6. conglomerate; 7. coal; 8. granite. Modified from Hatai and Kamada, 1950.

Fauna of the Iwaki Fm. at Joban

ARTIODACTYLA

ENTELODONTIDAE

— *Entelodon* sp.; cited by Tomida, pers. com., 1984
(= "*Anthracothema*" *tsuchiyai* Takai, 1961 (nomen nudum))

Source : MNHN, Paris

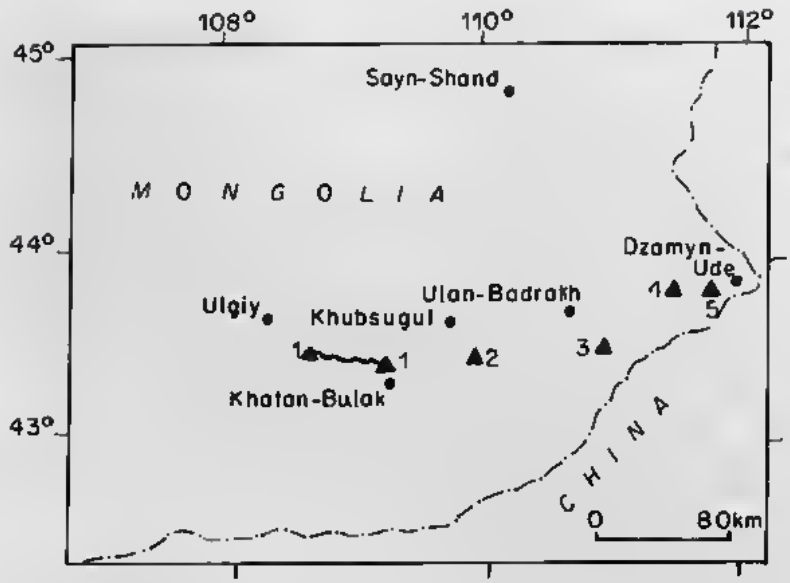


FIG. 156. — Sketch map showing the position of the principal Eocene and early Oligocene localities in southeast Mongolia. 1. Ergilin-Dzo; 2. Gua-Teg; 3. Alag-Tsav (late Eocene); 4. Khoer-Dzan (1, 2 and 4, early Oligocene); 5. Mergen (middle Eocene). Modified from Yanovskaya, Kurochkin & Devyatkin, 1977.

Lat. 43° 29′ N, approx.
Long. 109° E, approx.

Fig. 1, n° 28

MONGOLIA

DORNOGOBI PROVINCE

Ergilin-Dzo Svita — **early Oligocene**

Locality: Ergilin-Dzo

The fossil beds called collectively Ergilin-Dzo[44] were discovered in 1922 by the American Museum Central Asiatic Expedition and exploited more fully the following year. Further collecting was made in 1946-1949 by the Soviet Union, in 1958 and 1965 by Mongolian scientists, and in 1963 by the Polish-Mongolian Paleontological Expedition; in 1970, 1971 and 1974, a team of the Soviet-Mongolian Paleontological Expedition, led by Kurochkin, also worked in the area.

The fossiliferous region is situated in the southeast Gobi; its eastern extremity is 15 km north of the county seat of Khatan-Bulak[45] and 350 km south of the town of Sayn-Shand[46]. The "locality" extends over 45-50 km; fossiliferous sites are scattered along a north-facing series of cliffs and ravines that pass upward (and southward) onto a vast plateau. Forming a sequence from east to west, the following sites are known, beginning with the ravine of Ergil'Obo[47], the Novozhilov[48] hills, Sevkhul-Khuduk[49], Ikh-Uldziyn[50], Amar-Uldziyn[51], Aman-Us[52], Aman-Us-

44 Ergilin-Dzo (= Ergelin-Dzo = Erghilyin-Dzo = Ergilyn-Dzo = Ergelyeen-Dzo) = overturned back; or, where one turns back.
45 Khalan-Bulak = spring of the princess.
46 Sayn-Shand = nice springs.
47 Ergil' Obo (= Ardyn Obo) = overturned; or, the obo where one turns back.
48 Novozhilov Hills, named after the Soviet Geologist N. I. Novozhilov.
49 Sevkhul'-Khuduk = refreshing well.
50 Ikh-Uldziyn = big peace.
51 Amar-Uldziyn = tranquil serenity = peace.
52 Aman-Us = drinking water.

Source : MNHN, Paris

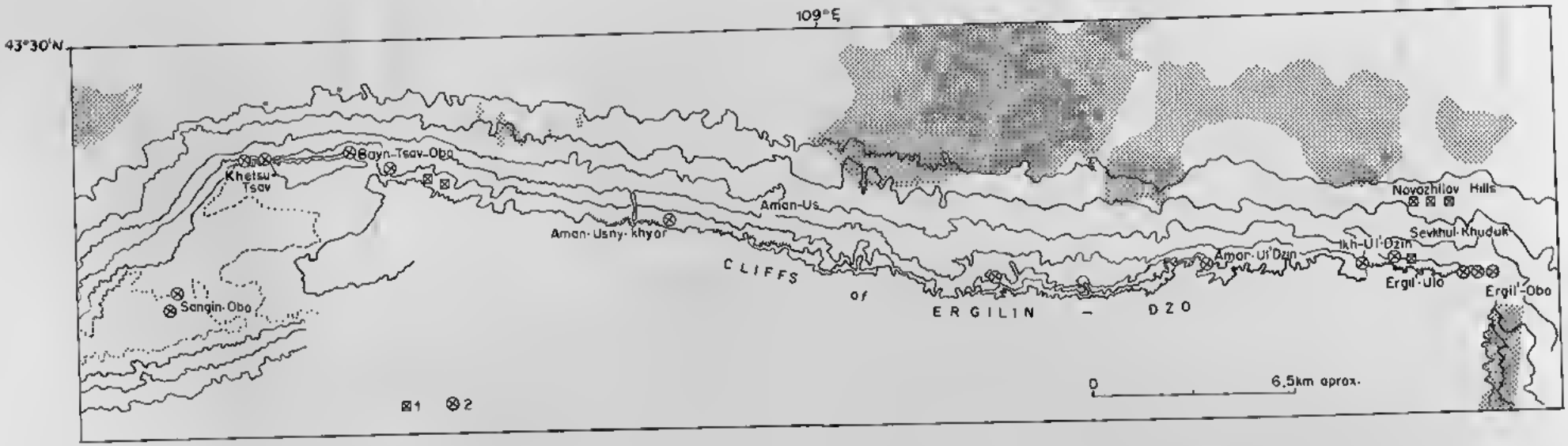


FIG. 157. — Region of Ergilin-Dzo, Mongolia, showing the position of the localities: **1**. site of excavations; **2**. surface finds. The cliffs descend towards the north. Shaded areas represent sand. Modified from Yanovskaya, Kurochkin & Devyatkin, 1977.

Source : MNHN, Paris

ny-Khyar[53], Bayan-Tsav[54], and Khetsu-Tsav[55]. The most complete section is in the eastern part of the ravine situated near the county seat of Khatan-Bulak.

The upper levels contain gray, gravely sands, pink sands and sands and clays ochre in color; the lower level is made up of gray sands, occasionally cemented to form friable sandstone; yellow coarse sands contain infrequent conglomerates. Lake deposits are present: white quartzitic sands lying on red and greenish clays. In the eastern part of the hills there is a strongly carbonated level (with white sand and numerous calcareous concretions).

The Ergilin-Dzo Svita is isolated at top and bottom by erosional unconformities; it overlies rocks of either Paleozoic or late Cretaceous age, and is capped by Quaternary sands and gravels. Its thickness is from 80 to 100 m.

For Berkey and Morris (1927), the beds all represent a same age; Rozhdestvenskiy (1949) subdivided them into horizons and Dashzeveg (1966) into 3 formations of different ages. According to the results of the Soviet-Mongolian Expeditions, the beds may be considered to represent a single unit of early Oligocene age (see Yanovskaya, Kurochkin and Devyatkin, 1977).

The Khetsu-Tsav beds, uppermost in the Ergilin-Dzo sequence, are typically sands, sandstones and conglomerates. The remains of fossil mammals are rare in them and when found they are frequently in fragmentary condition. The following forms are known from this level: brontotheriid indet., *Ardynia praecox*, *Cadurcodon ardynensis* and amynodontid indet.

The Ergilin-Dzo beds *sensu stricto*, the central section of the Ergilin-Dzo Svita, are divided into upper and lower parts. The upper part has furnished a rich and varied material. Nearly all the taxa collected during the 1970-1971 field campaign from this upper part were found in one or the other of two particularly rich sites. One, near Sevkhul'-Khuduk, and near the middle of the section, in a lens 0.5 - 1 m thick and extending over 10-12 m, furnished many bones and teeth of small vertebrates, recovered largely by the use of screen-washing. The second site, 1.5 - 2 km east of Bayan-Tsav-Obo, is situated at the base of the upper Ergilin-Dzo beds in a horizon of red clay and sand, with characterizing argillaceous concretions 10 - 15 cm in diameter. In places, the remains of large and middle sized mammals are scattered in profusion, particularly those of amynodontids.

The lower part of the Ergilin-Dzo beds has yielded fossils practically throughout the locality. But the only concentration found was a pocket near Sevkhul'-Khuduk in a layer of whitish, friable sandstone containing small vertebrates. The remains of two forms, in nearly equal numbers, dominated the assemblage: *Lophiomeryx angarae* and *Lophiomeryx gobiae*. Other taxa in the site were *Ardynomys olseni*, Carnivora indet., and *Miomeryx altaicus*.

The Novozhilov Hills constitute one of the richest localities in the whole Ergilin-Dzo region.

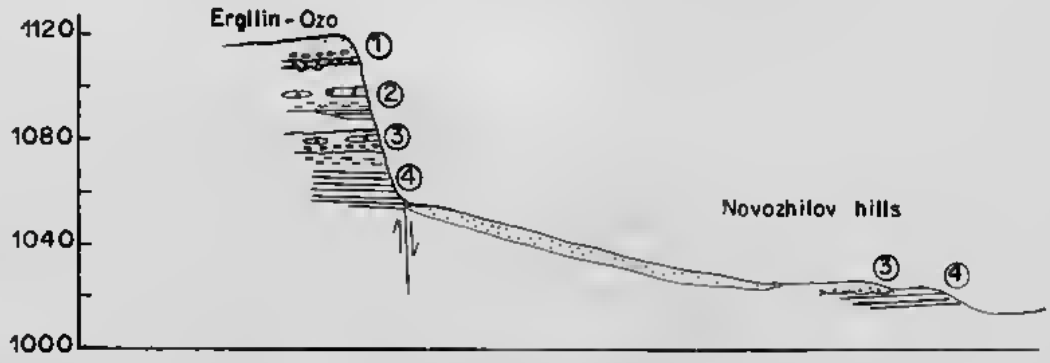


FIG. 158. — Cross section between Ergil'-Ula (to the south) and the Novozhilov Hills (to the north), Mongolia. 1 the Khetsu-Tsav beds; 2. the upper (alluvial) beds of the Ergilin-Dzo Svita; 3. the lower (lacustrine) beds of the Ergilin-Dzo Svita; 4. the Khubsugul beds. Modified from Yanovskaya, Kurochkin & Devyatkin, 1977.

53 Aman-Usny-Khyar = the crest (khyar) where there is drinking water.
54 Bayan-Tsav = rich cliff.
55 Khetsu-Tsav = difficult cliff.

Source : MNHN, Paris

Both the lower part of the Ergilin-Dzo beds and the Khubsugul beds crop out in these hills and the latter have been considered by some workers (see Gromova 1954, Yanovskaya 1954 and Dashzeveg 1966, 1971) as late Eocene. Dashzeveg (1974) published a complete faunal list of the Ergilin-Dzo locality, but apart from those that he personally collected, the level of origin of most of the taxa could not be precisely determined. The 3 month-long investigations and collections made by the expedition of 1970-1971 at the locality remedied this situation to a large degree. For the first time an accurate biostratigraphy, utilizing nearly all of the known taxa, could be presented (Yanovskaya *et al.*, 1977). While this has been salutory for the upper and middle beds of the sequence, no list was given of the forms found in the Khubsugul beds. At the time of its description, *Protembolotherium efremovi*, from a low but unidentified level, was considered on the basis of its stage of evolution to represent an epoch very late in the Eocene. However, in view of the other brontotheriid genera found associated with further remains of this species in 1970-1971 (but again the bed was not specified), Yanovskaya *et al.* (1977) regarded it as uncontestably early Oligocene. Two other forms that are frequently mentioned as being from a level low in the section are *Caenolophus promissus* and *Sharamynodon mongoliensis*. Both are, in fact, also found in the Nei Mongol (Chinese) Shara Murun late Eocene locality and the latter also occurs in the late Eocene faunas of Wucheng, Heti and Liankan. Moreover, an important element typical of the late Eocene can be discerned throughout the Ergilin-Dzo assemblage, exemplified by *Parabrontops gobiensis, Gigantamynodon, Epimanteoceras, Metatitan* and *Ictopidium*. For the present the problem of the age of the Khubsugul beds cannot be resolved, lacking faunistic data, but we accept its inclusion as a lithologically distinct unit in the Ergilin-Dzo Svita *sensu lato*, following Yanovskaya *et al.* (1977) and Devyatkin (1981).

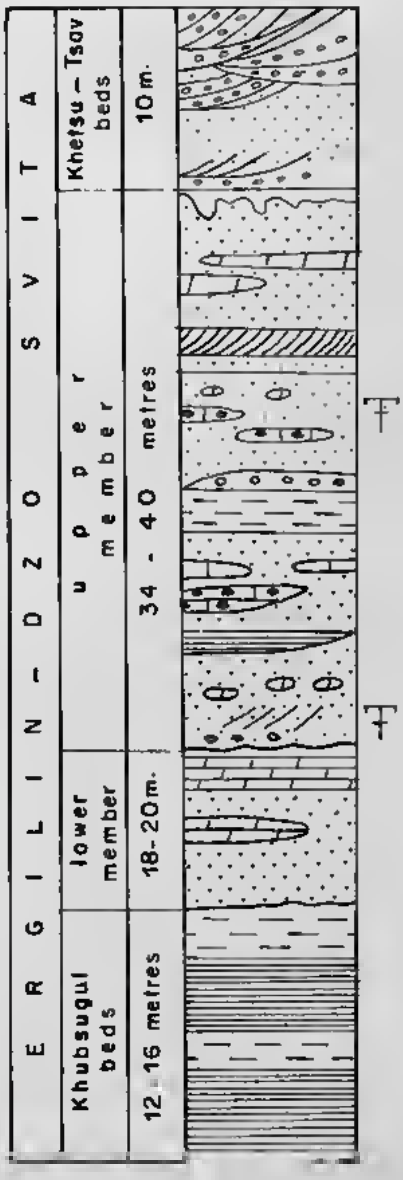


FIG. 159. — Reference section of the Ergilin-Dzo Svita at Ergil-Obo, Mongolia, with indication of the fossiliferous levels. Note that other authors (for example, Dashzeveg, 1971; Liskun & Badamgarav, 1977) do not include the Khetsu-Tsav and Khubsugul beds in the Ergilin-Dzo Svita, but consider them as separate svitas. Modified from Yanovskaya, Kurochkin & Devyatkin, 1977.

According to Dashzeveg (1985) an excellent outcrop of the Khubsugul beds is found at Shavag, 30 km north of Ergilin-Dzo. From the recovered fauna he regards the beds as early Oligocene. In the same section at Shavag deposits of middle Oligocene age overlie concordantly the Khetsu-Tsav beds, a situation that is unique in Mongolia.

A reasonable correlation can be established between the Ergilin-Dzo fauna and the Ulan Gochu, Urtyn Obo and Baron Sog faunas, with *Embolotherium andrewsi, Titanodectes ingens, Metatitan relictus, Schizotherium avitum, Ardynomys* and *Cadurcodon* constituting the forms in common.

Correlation with Europe is possible to some degree: *Hyaenodon, Pterodon* and *Cynodictis*

Source : MNHN, Paris

occur in common in the late Eocene; *Hyaenodon dubius*, *Entelodon* and *Lophiomeryx* typify the early Oligocene; *Hyaenodon*, *Schizotherium* and *Cadurcotherium* are found in the middle Oligocene. This series would seem to indicate that the Ergilin-Dzo fauna is closest to that of the early Oligocene of Europe, as *Schizotherium* probably arose earlier in Asia.

Early Oligocene brontotheres (*Brontops* and *Menodus*), *Teleolophus* and *Colodon* also permit a loose correlation with North America.

As the whole of the Ergilin-Dzo assemblage, by the presence of the same taxa both high and low in the section, shows little indication of a significant time lapse, we conclude that the entire fauna represents a period early in the Oligocene.

Faunal lists from the Ergilin-Dzo Svita arranged stratigraphically

(from Yanovskaya *et al.*, 1977, unless otherwise indicated)

Khetsu-Tsav: Brontotheriidae indet.
Ardynia praecox
Cadurcodon ardynensis
Amynodontidae indet.

Ergilin-Dzo beds (upper part)	**Ergilin-Dzo beds (lower part)**
* *Palaeoscaptor*? sp.	
* *Ictopidium*?	
* Soricinae indet.	(faunal assemblage lumped with that of the Khubsugul beds)
* Lagomorpha indet.	
* *Ardynomys olseni*	• *Ardynomys olseni*
* *A. vinogradovi*?	
* *Morosomys silentiumis*?	
* *Eumys* sp.	
* Carnivora indet.	• Carnivora indet.
* *Hyaenodon* sp. (big form)	*Hyaenodon eminus* (cited by Dashzeveg, 1975)
* *Pterodon mongoliensis*	
* Condylarthra? indet.	n *Protembolotherium efremovi*
** *Epimanteoceras* sp.	n *Epimanteoceras robustum*
** *Embolotherium andrewsi* (and cited by Dashzeveg, 1975)	n *Embolotherium andrewsi*
	n *Embolotherium* sp.
** Brontotheriidae indet.	n *Parabrontops gobiensis*
** *Schizotherium avitum* (and cited by Dashzeveg, 1975)	n *Metatitan relictus*
	n *Titanodectes ingens*?
	• Brontotheriidae indet.
Colodon sp.	n *Colodon*? sp.
** *Ardynia praecox*	• *Ardynia praecox*
** Hyracodontidae indet. (small form)	• Hyracodontidae indet. (small form)
	n *Caenolophus promissus*
** *Cadurcodon ardynensis*	n *Cadurcodon ardynensis*
** *Gigantamynodon cessator*	• *Gigantamynodon cessator*
Cadurcotherium progressus	n *Sharamynodon mongoliensis*
** Amynodontidae indet. (small form (same as at Novozhilov Hills)	n Amynodontidae indet. (same as that from upper part of Ergilin-Dzo beds)
** *Brachyodus* sp.	• *Lophiomeryx angarae*
** Anthracotheriidae indet.	• *Lophiomeryx gobiae*
* *Lophiomeryx angarae*	• *Miomeryx altaicus*
*, ** *Lophiomeryx* sp.	
* = from a lens at Sevkhul'-Khuduk	• from the Novozhilov Hills
** = from east of Bayan-Tsav Obo	n found elsewhere at Ergilin-Dzo

Source : MNHN, Paris

Fauna of the Ergilin-Dzo Svita at Ergilin-Dzo

INSECTIVORA

ERINACEIDAE
— *Ictopidium*? sp.; cited by Yanovskaya *et al.*, 1977
— *Palaeoscaptor*? sp.; cited by Yanovskaya *et al.*, 1977

SORICIDAE
— Soricinae indet., cited by Yanovskaya *et al.*, 1977

LAGOMORPHA

OCHOTONIDAE
— *Desmatolagus robustus* Matthew & Granger, 1923d
— family indet., cited by Yanovskaya, *et al.*, 1977

RODENTIA

CYLINDRODONTIDAE
— *Ardynomys olseni* Matthew & Granger, 1925b
(= *Ardynomys chihi* Matthew & Granger, 1925b, *in* Wood, 1970)
— *Ardynomys*? *vinogradovi* Shevyreva, 1972
— *Morosomys silentiumis* Shevyreva, 1972
(= *Morosomys silenti, in* Yanovskaya *et al.*, 1977)

CRICETIDAE
— *Eucricetodon* sp.
(= *Eumys* sp.; cited by Yanovskaya *et al.*, 1977)

CARNIVORA

CANIDAE?
— *Cynodictis*? sp.; cited by Dashzeveg, 1974

CREODONTA

HYAENODONTIDAE
— *Hyaenodon eminus* Matthew & Granger, 1925b
(= *Hyaenodon dubius* Filhol, 1873; cited by Gromova, 1952a; contested by Dashzeveg, 1974 and 1985)
— *Hyaenodon dubius* Filhol, 1873, re-affirmed by Lange-Badré, 1979
— *Hyaenodon* sp. (large form); cited by Yanovskaya *et al.*, 1977
— *Pterodon mongoliensis* (Dashzeveg, 1964) Van Valen, 1967
(= *Megalopterodon mongoliensis* Dashzeveg, 1964; and in Dashzeveg, 1974)

PERISSODACTYLA

BRONTOTHERIIDAE
— *Metatitan relictus* Granger & Gregory, 1943; cited by Yanovskaya *et al.*, 1977
(= *Metatitan* sp.; cited by Belyayeva *et al.*, 1974)
— *Parabrontops gobiensis* (Osborn, 1925) Granger & Gregory, 1943
(= *Brontops gobiensis* Osborn, 1925)
— *Protembolotherium efremovi* Yanovskaya, 1954
— *Titanodectes ingens*? Granger & Gregory, 1943
(or *Embolotherium* sp., *in* Granger & Gregory, 1943)
(= *Menodus mongoliensis* Osborn, 1925)
— *Embolotherium ergilense* Dashzeveg, 1975
— *Embolotherium andrewsi* Osborn, 1929; cited by Yanovskaya *et al.*, 1977
— *Epimanteoceras robustum* (Granger & Gregory, 1943); cited by Yanovskaya *et al.*, 1977
(= *Protitan robustus* Granger & Gregory, 1943, *in* Yanovskaya *et al.*, 1977)
(= *Epimanteoceras amplus* Yanovskaya, 1976, *in* Yanovskaya *et al.*, 1977)

CHALICOTHERIIDAE
— *Schizotherium avitum* Matthew & Granger, 1923b

HELALETIDAE
— *Colodon inceptus* Matthew & Granger, 1925c
(= *Paracolodon curtus* Matthew & Granger, 1925c, *in* Radinsky, 1965)
— *Colodon* sp.; cited by Yanovskaya *et al.*, 1977

Source : MNHN, Paris

HYRACODONTIDAE[56]
— *Ardynia praecox* Matthew & Granger, 1923b
(= *Ergilia pachypterna* Gromova, 1952b, *in* Radinsky, 1967)
(= *Parahyracodon mongoliensis* Gromova, 1952b, *in* Radinsky, 1967)
— *Forstercooperia ergiliiensis* Gabunia & Dashzeveg, 1974

RHINOCEROTIDAE
— *Ronzotherium brevirostris* (Belyayeva, 1954c) Heissig, 1969
— (= *Symphysorrachis brevirostris* Belyayeva, 1954c)

AMYNODONTIDAE
— *Caenolophus promissus* Matthew & Granger, 1925d
— *Cadurcodon ardynensis* (Osborn, 1923c) Kretzoi, 1942
(= *Cadurcotherium ardynense* Osborn, 1923c; see also Osborn, 1924c)
— *Gigantamynodon cessator* Gromova, 1954
— *Cadurcotherium progressus* (Gromova, 1954) Wall, 1982b
(= *Hypsamynodon progressus* Gromova, 1954)
— *Sharamynodon mongoliensis* (Osborn, 1936) Kretzoi, 1942
(= *Amynodon mongoliensis* Osborn, 1936)

ARTIODACTYLA

ENTELODONTIDAE
— *Entelodon gobiensis* (Trofimov, 1952b) Brunet 1979
(= *Brachyodon gobiensis* Trofimov, 1952b)
(= *Ergilobia gobiensis* (Trofimov, 1952b) Trofimov, 1958)
— *Entelodon*? sp., *in* Brunet, 1979
(= *Archaeotherium*? sp., *in* Trofimov, 1952b)

ANTHRACOTHERIIDAE
— *Brachyodus*? sp.; cited by Yanovskaya *et al.*, 1977; questioned by the authors[57]
(= Anthracotheriidae indet., cited by Dashzeveg, 1974)

LEPTOMERYCIDAE
— *Miomeryx altaicus* Matthew & Granger, 1925c
— *Miomeryx* sp.; cited by Yanovskaya *et al.*, 1977
— *Gobiomeryx dubius* Trofimov, 1957

CERVIDAE
— *Eumeryx* sp.; cited by Matthew & Granger, 1923b

GELOCIDAE
— *Lophiomeryx angarae* Matthew & Granger, 1925c
— *Lophiomeryx gobiae* Matthew & Granger, 1925c[58]

ORDER Indet.

DIDYMOCONIDAE
— *Ardynictis furunculus* Matthew & Granger, 1925b

Lat. 43° 45′ N, approx.
Long. 111° 45′ E, approx.

Fig. 1, n° 31

MONGOLIA

DORNOGOBI PROVINCE

Ergilin-Dzo Svita **early Oligocene**

Locality: Khoer-Dzan

The Khoer-Dzan[59] locality was discovered by Dashzeveg in 1962. Intensive collecting was done in 1970-1971 by the Soviet-Mongolian team led by Kurochkin at this site, which is located

56 *Urtinotherium incisivum* Chow & Chiu, 1963 was cited in error from Ardyn-Obo (part of the Ergilin-Dzo cliffs) by Radinsky, 1967, p. 37; the material described by Chow & Chiu was from Urtyn Obo, Inner Mongolia.
57 This genus is known only in the Miocene of Europe and Africa.
58 Cited in error by Zhang *et al.*, 1978, as *L. gebiae*.
59 Khoer-Dzan = two elephants; so named because of the profiles created by the Ikh-Dzan and Boga-Dzan buttes.

Source : MNHN, Paris

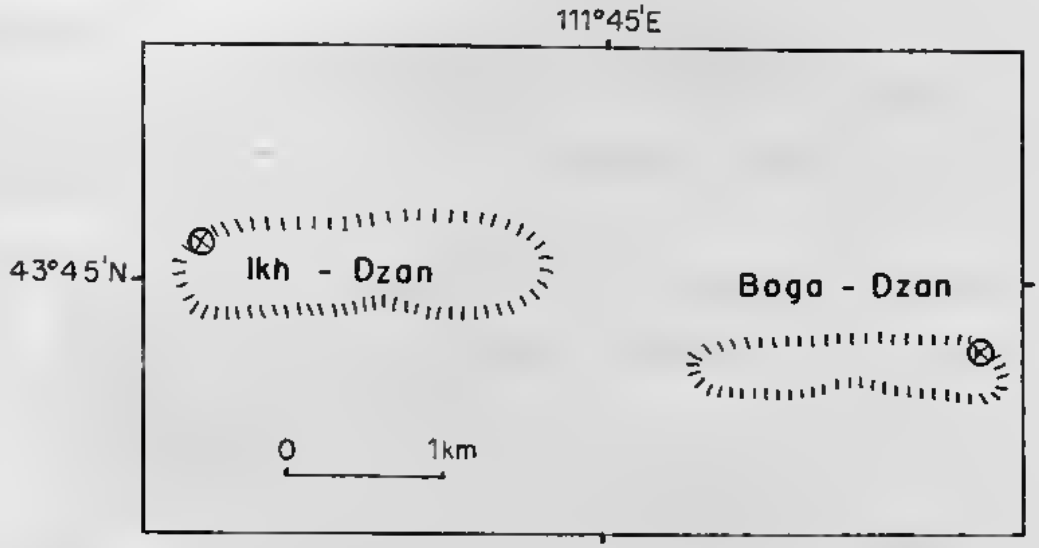


FIG. 160. — Sketch map of the two buttes, Ikh-Dzan and Boga-Dzan, that constitute the locality of Khoer-Dzan, Mongolia. Provided by Dashzeveg, pers. com., 1985.

200 km east of Ergilin-Dzo and 50 km southwest of the railroad station of Dzamyn-Ude[60] at the southern border of the East Gobi Province. Many mammalian fossils were discovered in the upper part of the section, in ochre crossbedded sands of variable grain size. A complete geologic description of the locality has not yet been published, but Dashzeveg (1976c) noted the presence of two fossiliferous levels. In 1985 he noted that most of the fossils came from the upper levels. The basal part of the section is only visible 1 km NW of the ravine containing the principal locality of Ikh-Dzan[61]. In this basal part the fossiliferous level of concretionary sandstone and gravels is situated well below the lacustrine horizon of Ergilin-Dzo; it has yielded *Lophiomeryx*, mesonychids and brontotheres. For Dashzeveg, this level correlates with the oldest Ergilin-Dzo strata (the Khubsugul beds) at Shavag.

The similarity of the fauna as a whole to that of Ergilin-Dzo permits its correlation with the latter and establishes its age as early Oligocene. The small assemblage of mammals from Urtyn Obo is also regarded as approximately contemporaneous.

Other small and, so far, unimportant sites in the southeast Gobi include Khulst[62] Hill, discovered by the 1963 Polish-Mongolian Paleontological Expedition. Indeterminate remains of mammals were found in a sandstone of unknown (probably Oligocene) age.

During the same expedition a bone-bearing level, particularly rich in the well preserved remains of large tortoises, was found at Gua-Teg, a locality situated about 70 km from Ergilin-Dzo and 32 km SE of the somon (= county seat) of Khubsugul. The sediments are referred to the Ergilin-Dzo Svita and the brontotheriid *Embolotherium andrewsi* Osborn, 1929, was cited by Yanovskaya (1980) from here.

From the same somon of Khubsugul, Yanovskaya (1980) cited *Parabrontops*? sp., but no locality name was given.

Several taxa ("*Aelurogale*" *mongoliensis*, *Amynodon giganteus*, *Cadurcodon ardynensis*) were described by Gromova (1958, 1959) and said to come from a locality called Sulan-Kher[63]. According to Dashzeveg (pers. com., 1985) this is the same place as Khoer-Dzan.

60 Dzamyn-Ude = gate of the road.
61 Ikh-Dzan = big elephant; Boga-Dzan = small elephant.
62 Khulst = with tall plants (rushes).
63 Sulan-Kher (= Solonkeur = Solenker = Sulanheer) = field (kher) of the plant genus *Stipa* (sul').

Source : MNHN, Paris

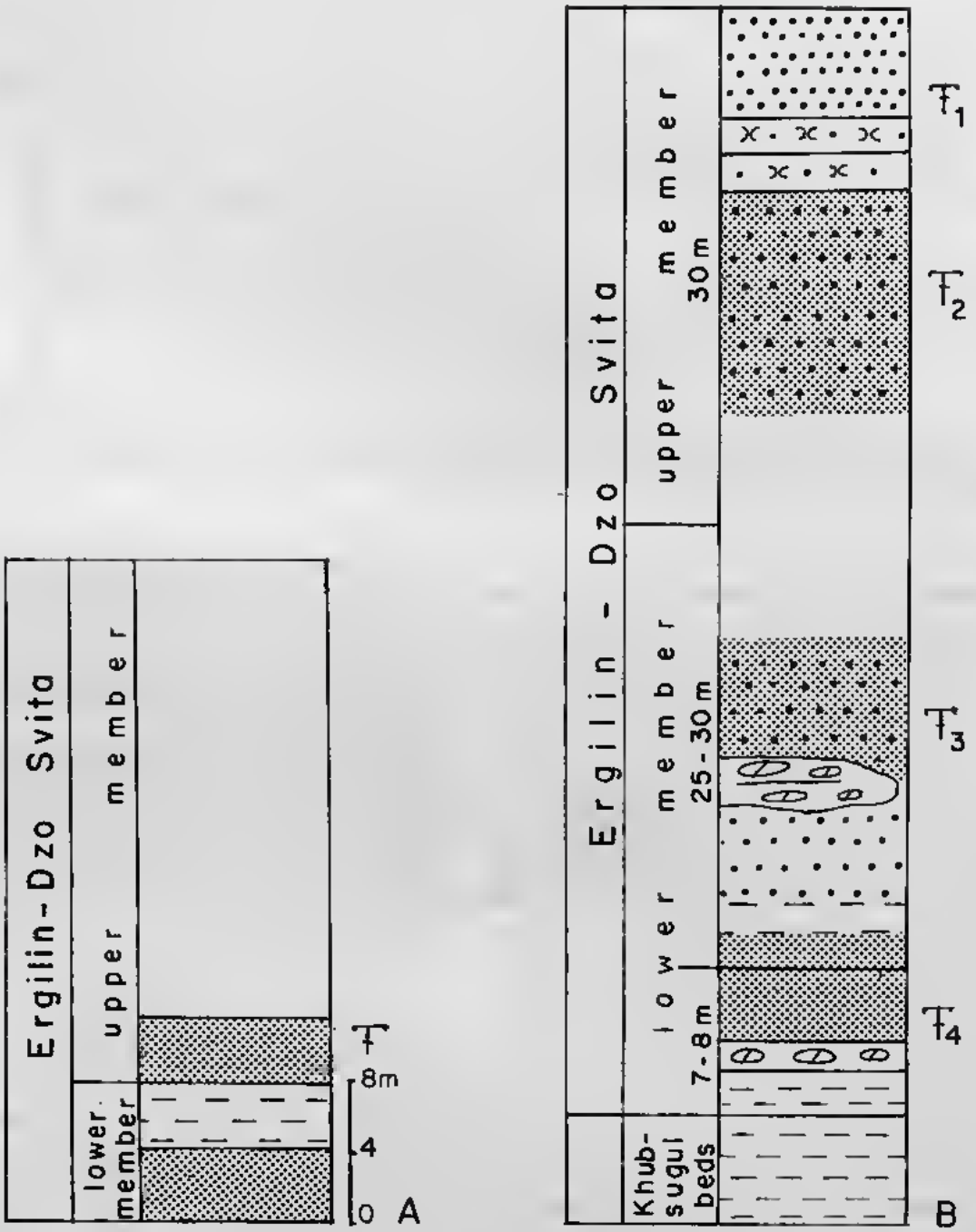


FIG. 161. — A. Stratigraphic section at the fossil locality of Boga-Dzan (Khoer-Dzan), Mongolia. Most of the upper member is covered and not observable. A lens of yellow sand at its base has furnished fossil mammals, such as *Embolotherium* sp. and *Cadurcodon ardynensis*. The white beds of the lower member are separated from the upper by a lens of red clay. The Khubsugul beds are absent here.

B. Stratigraphic section at the principal Khoer-Dzan locality, that at Ikh-Dzan, Mongolia. The Khetsu-Tsav beds are absent in the Khoer-Dzan region and the lower member of the Ergilin-Dzo Svita is divided into two levels. The contact between the upper and lower members is not visible in this section. F 3 is in white sand and the Khubsugul beds are made up of red clay. Data from Dashzeveg, pers, com., 1985.

Source : MNHN, Paris

Fauna of the Ergilin-Dzo Svita at Khoer-Dzan

taxa with asterisks were cited by Dashzeveg (pers. com., 1985) from the following levels (indicated on the stratigraphic section of Ikh-Dzan, Fig. 161):
* from F 1 and 2 in the upper member; ** from F 3 in the lower member; *** from F 4 in the lower part of the lower member.)

CARNIVORA

FELIDAE
— *Nimravus mongoliensis* (Gromova, 1959) Dashzeveg, pers. com., 1985
(= *Aelurogale mongoliensis* Gromova, 1959, V.P. (2))

CREODONTA

HYAENODONTIDAE
** — *Pterodon exploratus* Dashzeveg, 1985
— *Pterodon* sp.; cited by Dashzeveg, 1985
** — *Hyaenodon incertus* Dashzeveg, 1985
* — *Hyaenodon gigas* Dashzeveg, 1985
*** — *Hyaenodon* sp.; cited by Yanovskaya, 1980

CONDYLARTHRA

MESONYCHIDAE Indet.; cited by Dashzeveg, 1985

PERISSODACTYLA

BRONTOTHERIIDAE
** — *Embolotherium insigne* Yanovskaya, 1980
(= *Embolotherium grangeri* Osborn, 1929, according to Dashzeveg, pers. com., 1985)
— *Embolotherium andrewsi* Osborn 1929; cited by Yanovskaya, 1980
***, * — *Embolotherium* sp.; cited by Dashzeveg, pers. com., 1985
— *Metatitan relictus* Granger & Gregory, 1943; cited by Yanovskaya, 1980
— Brontotheriidae Indet.; cited by Yanovskaya, 1980

CHALICOTHERIIDAE
** — *Schizotherium avitum* Matthew & Granger, 1923b; cited by Dashzeveg, pers. com., 1985
(= *Schizotherium* sp.; cited by Kurochkin & Dashzeveg, 1979

DEPERETELLIDAE
** — *Teleolophus magnus* Radinsky, 1965; cited by Reshetov, 1979

HELALETIDAE
** — *Colodon inceptus* Matthew & Granger, 1925c; cited by Dashzeveg, pers. com., 1985

HYRACODONTIDAE
** — *Ardynia praecox* Matthew & Granger, 1923b; cited by Kurochkin & Dashzeveg, 1979
* — *Indricotherium parvum* Chow, 1958c; cited by Dashzeveg, 1976c
, * — *Prohyracodon* sp.; cited by Dashzeveg, pers. com., 1985

AMYNODONTIDAE
**, * — *Cadurcodon ardynensis* (Osborn, 1923c) Kretzoi, 1942; cited by Gromova, 1958, V.P. (2, 3)
(= *Cadurcotherium ardynense* Osborn, 1923c); cited by Kurochkin & Dashzeveg, 1979)
— *Amynodon giganteus* Gromova, 1958, V.P. (2, 3)
**, * — *Gigantamynodon cessator* Gromova, 1954; cited by Dashzeveg, pers. com., 1985
— *Gigantamynodon* sp.; cited by Kurochkin & Dashzeveg, 1979

FAMILY Indet.
— Indricothere or amynodont indet., *in* Lucas, 1982
(= *Hypercoryphodon* sp.; cited by Kurochkin & Dashzeveg, 1979

ARTIODACTYLA

ENTELODONTIDAE
** — *Eoentelodon trofimovi* Dashzeveg, 1976
* — *Entelodon orientalis* Dashzeveg, 1965
(= *Entelodon* aff. *major* Biryukov, 1961a, *in* Brunet, 1979)

Source : MNHN, Paris

ANTHRACOTHERIIDAE * — *Bothriodon* sp.; cited by Dashzeveg, pers. com., 1985
GELOCIDAE *** — *Lophiomeryx* sp.; cited by Kurochkin & Dashzeveg, 1979 (= Traguloidea indet.; cited by Yanovskaya, 1980)

Lat. 43° 55' N
Long. 109° 55' E

Fig. 1, n° 29

MONGOLIA

DORNOGOBI PROVINCE

Ergilin-Dzo Svita **early Oligocene**

Locality: Gua-Teg

The Gua-Teg[64] locality was discovered by the Polish-Mongolian Paleontological Expedition of 1963 and has been further exploited in the early 1980's by Dashzeveg. It is situated 32 km south-east of the county seat (somon) of Khubsugul.

The Ergilin-Dzo Svita in this area is about 30 m thick; it does not differ appreciably from outcrops at Ergilin-Dzo.

The fauna from this site has not yet been described.

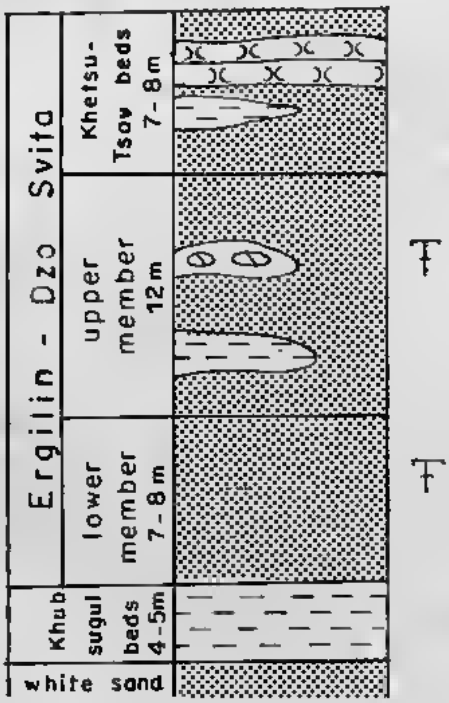


FIG. 162. — Stratigraphic section at the fossil locality of Gua-Teg, Mongolia. The Khubsugul beds are red clays and the lower member is white sand. The Khetsu-Tsav beds form the surface of the outcrop in this area. Data from Dashzeveg, pers. com., 1985.

Fauna of the Ergilin-Dzo Svita at Gua-Teg

(* from upper member; ** from lower member)

PERISSODACTYLA

HYRACODONTIDAE * — *Ardynia praecox* Matthew & Granger, 1923b; cited by Dashzeveg, pers. com., 1985
AMYNODONTIDAE * — *Cadurcodon ardynensis* (Osborn, 1923c) Kretzoi, 1942; cited by Dashzeveg, pers. com., 1985
(= *Cadurcotherium ardynense* Osborn, 1923c)
** — *Cadurcodon* sp.; cited by Dashzeveg, pers. com., 1985

64 Gua-Teg = a pretty sort of plateau.

Source : MNHN, Paris

Lat. 45° 20′ N, approx.
Long. 100° 45′ E, approx

Fig. 1, n° 19

MONGOLIA
OBOR-KHANGAY PROVINCE
Valley of Lakes

Ergilin-Dzo Svita analog **early Oligocene**
Locality: Menkhen-Teg

The lack of early Oligocene faunas in the Valley of Lakes has not prevented the identification of sediments of this age. Cropping out principally along the north and south borders of the Valley of Lakes depression, a reference section has been chosen for them at Menkhen-Teg[65]. There, they overlie disconformably the late Eocene Kholboldzhi-Nur Svita and grade up into the red clays of the Shand-Gol Svita. The early Oligocene section begins with quartzitic sand and pebbles (5-7 m), followed by a dominance of pelites and marly clays (6-8 m) and terminates with beds of sand and gravel (10-12 m) (total thickness: 21-27 m). In the sands and gravels Devyatkin (1981) noted the presence of large mammal bones and fragments of "rhinoceros" dental enamel. A section given by Badamgarav *et al.* (1975) differs from that of Devyatkin, and no fossils are mentioned.

Fauna of the Ergiin-Dzo Svita analog at Menkhen-Teg

PERISSODACTYLA
HYRACODONTIDAE Indet.; cited by Devyatkin, 1981

Lat. 48° 45′ N, approx.
Long. 73° 45′ E, approx.

Fig. 3, n° 9

U.S.S.R.
KAZAKH S.S.R.
Dzhezkazgan Oblast'

unnamed svita **late Eocene?**
Locality: Aksoran **middle Oligocene?**

The Institute of Zoology and Geology of the Academy of Sciences of the Kazakh S.S.R. collected in 1951 the first brontotheriid remains known in the Soviet Union. Later (in 1952 and 1954), Kuznetsov found fossils referable to "*Allacerops*" and other vertebrates in the same place. The locality occurs 90 km to the NE of Agadyr' in the region of the headwaters of the Sary-Su River, on a stream also called Aksoran. Yanovskaya (1953) described the brontothere material and concluded it represented an Eocene form from the "early part of the late

65 See Fig. 76 in the discussion of this locality in the late Eocene chapter.

Source : MNHN, Paris

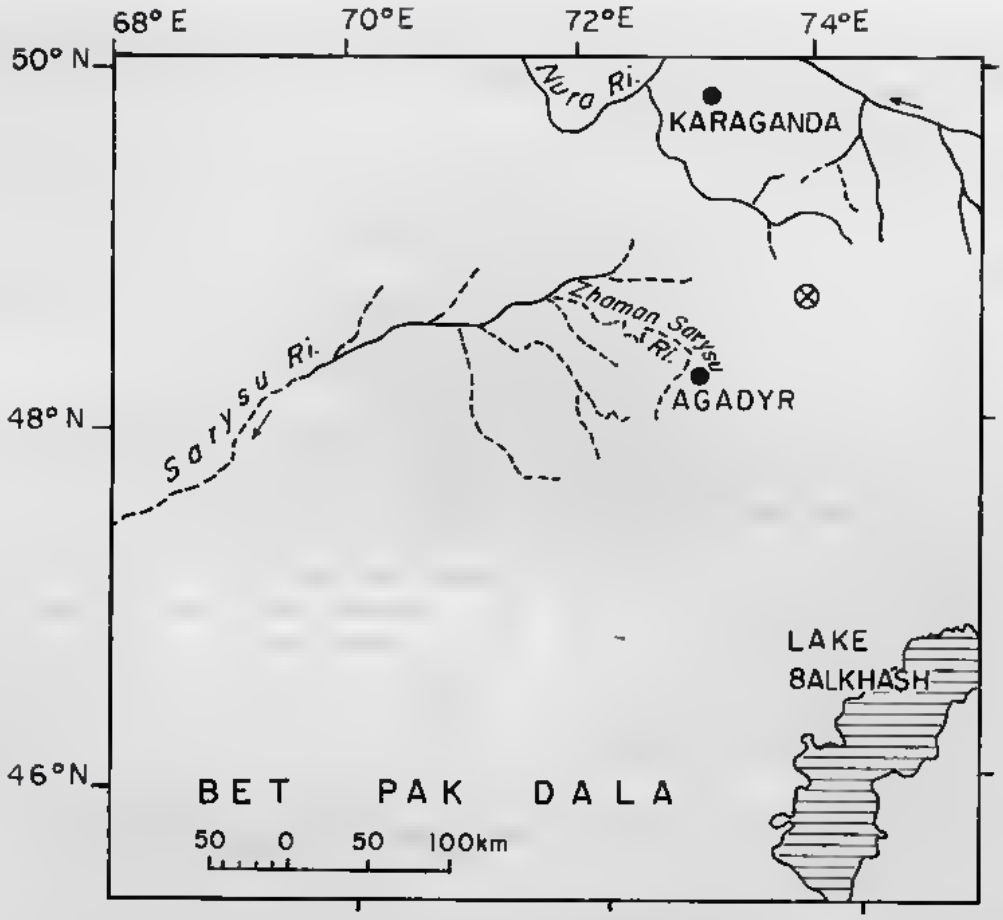


FIG. 163. - The Aksoran fossil locality is found in the region of the Agadyr' railroad station, Kazakh S.S.R. Modified from the Atlas Mira, Moscow, 1954.

Eocene". In a regional account of the geology, Bazhanov (1962) noted the deposition along the eastern margin of the Turgay Depression of an extensive accumulation of cherry red gravelly clays. According to him the fossils collected at Aksoran came from a thin bed of these clays. Yanovskaya (1953), however, indicated that the collection was made in the chimney of a karst and that the deposit was reworked. Bazhanov (1955), in fact, also remarked that the sediments were apparently mixed and redeposited.

The association of *Epimanteoceras* with affinity to the middle Eocene Ulan Shireh form of China, and "*Allacerops*" *turgaica* from the middle Oligocene (Chelkar-Teniz and Myneske-Suyek) and late Oligocene (Saroy) of Kazakhstan suggests that either a faunal mixture is present or that an error in age appreciation was made. As Yanovskaya (1980) has pointed out, *Epimanteoceras* also occurs in the early Oligocene at Ardyn-Obo, Mongolia. Analysis of the rodent material might prove informative.

In the absence of conclusive evidence, we will retain the late Eocene age suggested by Yanovskaya for at least part of the deposits, but it is possible that it also contains Oligocene sediments.

Fauna at Aksoran

RODENTIA

CYLINDRODONTIDAE Indet.; cited by Bazhanov, 1962

PERISSODACTYLA

BRONTOTHERIIDAE — *Epimanteoceras praecursor* Yanovskaya, 1953

Source : MNHN, Paris

HYRACODONTIDAE — *Eggysodon turgaicus* (Borisyak, 1915) Brunet, 1979
(= *Epiaceratherium turgaicum* Borisyak, 1915)
(= *Allacerops turgaica* (Borisyak, 1915) Radinsky, 1967); cited by Bazhanov, 1962)

U.S.S.R.
KAZAKH S.S.R.
Voshtochno Kazakhstanskaya Oblast'
Zaysan Depression

Middle Aksyir Subsvita **early Oligocene**

Localities: Areal Site VI, Kiin-Kerish Mountain; Areal Site VIII, Bulkain Valley (Cherep); Koksaldy River (Sunduk)

In the middle part of the Aksyir Svita finds of fossil mammals are few. Those that are known were discovered by Shevyreva and Chkhikvadze in the 1960's and 70's at Kiin-Kerish Mountain and on the Bulkair and Koksaldy Rivers. At Kiin-Kerish Mountain mammalian sites are situated on its western slopes; the middle Aksyir here is gently dipping and has a thickness of 5-6 m. On the Bulkair River the svita is nearly horizontal and the middle subsvita is about 10 m thick. On the southern slopes of Cherep[66] Hill Chkhikvadze and Shevyreva discovered a skull of a brontothere, which was attributed to the early Oligocene by Yanovskaya (1980). It was found immediately below a bed of leaf imprints situated 3 m from the base of the middle Aksyir subsvita that can be observed in all the Paleogene outcrops in this area of the Zaysan Basin. On the Koksaldy River the Aksyir Svita is folded into a steep-sided anticline. Outcrops of the middle part of the svita are poorly exposed. The mammalian remains come from a site situated 1.5 m below the boundary between the middle and upper subsvitas.

Fauna of the middle Aksyir Subsvita

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Yanovskaya, 1980

U.S.S.R.
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Voshtochno Kazakhstanskaya Oblast'
Zaysan Depression

Upper Aksyir Subsvita **early Oligocene**

Localities: Areal Site VI, Kiin-Kerish Mountain; Tayzhuzgen River (Dzhal'ma); Areal Site X, between the Kusto and Kyzylkain Rivers; junction of the Konurkura and Dzhamangora Rivers; Areal Site VIII, Bulkair Valley (Chernyy Kameni, Bublik, Grib); Karasu River (Maylibay); Kenderlyk River (Mogila Sultan and/or Tabtym); Areal Site II, Kalmakpay River; Areal Site V, Aksyir River (Yuznaya Kuesto — levels 82-84, 55-56, 52, 47-49, 36-37, and Pyat Kameney); Chakpaktas River; Koksaldy River (Sunduk: Zertsalo, Krasnyy Lishaynik, Rozovyy Valun); Areal Site IX, Akkolka River

66 Cherep = skull.

Source : MNHN, Paris

In the Zaysan Basin the upper part of the Aksyir Svita yields fossil vertebrates in nearly all the Paleogene outcrops. After the Obayla Svita and the lower part of the Aksyir this is the most fossiliferous horizon of the basin. The first discoveries of mammals were made in 1939-1940 by N. N. Ochurkov and V. G. Betekhtina along the Tayzhuzgen[67] River. According to Borisov (pers. com., 1985), both Bazhanov and Ryabinin reported the presence of condylarths in this collection; this identification now seems unlikely. Later, in the 1960's and 70's, the number of producing localities greatly increased. Among the most important are those at Kiin-Kerish Mountain and along the Bulkair Valley and the Aksyir, Koksaldy and Akkolka Rivers.

At Kiin-Kerish Mountain, still on the western slopes, it was V. K. Vasilenko who was the first to find (in 1953) fossil vertebrates at different stratigraphic levels, but the first real collections were made by paleontologists from the Academy of Sciences of Kazakhstan (V. S. Bazhanov, M. D. Biryukov, and others). The upper part of the Aksyir Svita, varying in thickness from 12 m at Biryukov Camp (= Lager' Biryukova) to about 20 m at Anchor Camp (Lager' Yakor'), includes mammal localities at several levels. The most productive level in small mammals is situated north of Camp Biryukov (at Tank Hill = sopka tank) about 2 m from the boundary between the middle and upper parts of the Aksyir Svita. A little higher (2-4 m), localities with the remains of larger mammals are found (at Biryukov Camp).

On the left bank of the Tayzhuzgen (Dzhal'ma locality)[68], near the top of the valley slope, there is an outcrop of horizontal clay with secondary intercalations of indurated sand. It is here, in the sediments of the upper Aksyir subsvita (with a thickness of 14 m), that the original discovery of mammals by Ochurkov and Betekhtina was made. North of this outcrop, and higher in the section, are outcrops of the Kusto Svita, while to the south, and stratigraphically lower, is found the middle part of the Aksyir Svita.

The Bulkair Valley, which at present lacks a stream, is actually a dry branch of the Karasu River; the left slope, as well as the southern part of this valley is covered with fragments of Gobi conglomeratic blocks. The upper part of the Aksyir Svita is about 15 m thick in this region. It is nearly horizontal and is unconformably overlain by the Kusto Svita. Chkhikvadze and Shevyreva (in the 1960's and 70's) have found fossil mammals in three horizons here: in the lower part (at Chernyy Kameni locality)[69], in the middle part (at Bublik locality)[70], and near the contact with the Kusto Svita (locality Grib)[71].

On the Aksyir River the principal mammal localities in the upper Aksyir subsvita were found on the south flank[72,73] of the first Aksyir anticline. With a gentle dip and a thickness of more than 20 m the subsvita overlies the middle part of the svita and is covered by a bed finely ribboned with alternating clays and silts, 5 m thick, which perhaps belongs to the Kusto Svita. Fossil mammals occur throughout the section of the upper part of the Aksyir Svita, particularly at the following levels (in ascending order): 2 m above the first orange argillaceous horizon, in the first red argillaceous level, between the first and second levels of red clay, in the second red clay level, the second orange and also 2 m above the latter.

The locality of Pyat Kameney is situated near the boundary between the middle and the upper parts of the Aksyir Svita (on the left bank of the Aksyir River and on the southern flank of the first anticline). According to Chkhikvadze the site is 1-3 m below the boundary, while Borisov is of the opinion that it occurs a little above the limit.

Near the Koksaldy River the upper Aksyir subsvita, concordant on the middle subsvita, has a steep dip and a thickness of about 20 m. It contains localities also discovered in the 1960's and 70's by Shevyreva and Chkhikvadze at the following levels: at .5 m above the first orange clay bed (at Krasnyy Lishaynik?)[74], 5 m above

67 Tayzhuzgen = where the colts swim.
68 Dzhal'ma = turban.
69 Chernyy Kameni = black rocks.
70 Bublik = cookie.
71 Grib = mushroom.
72 Yuznaya Kuesta = southern cuesta.
73 Pyat Kameney = five rocks.
74 Krashyy Lishaynik = red lichen.

Source : MNHN, Paris

the first orange clay bed (at Rozovyy Valun[75] locality), and in the second orange clay bed (Zertsalo locality).

Upstream on the Akkolka River fossil mammals have also been found by the team of Shevyreva and Chkhikvadze in the 60's and 70's. The Aksyir Svita is nearly horizontal here and its three subsvitas are overlain disconformably by the Buran Svita. The thickness of the middle part of the Aksyir Svita is about 10 m.

Refined determination of the groups cited in the faunal list (insectivores, rodents, brontotheres) would probably be fruitful for assigning an age to this part of the Aksyir Svita, but the genera that have been identified are of little significance: one is a Miocene form (*Brachyodus*, if correctly identified) and the other (*Archaeomeryx*) is typically from the middle or late Eocene. Based on the mammals no conclusion is possible for the moment.

Fauna of the Upper Aksyir Svita

(furnished by Dr. Shevyreva, Prof. Gabunia and Dr. Gureyev)

MARSUPIALIA

DIDELPHIDAE Indet.; cited by Gabunia, Shevyreva & Gabunia 1984 (and 1985)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

RODENTIA

PARAMYIDAE? Indet.; cited by Shevyreva, pers. com. 1981

CTENODACTYLIDAE Indet.; cited by Shevyreva, pers. com., 1981, as Chapattimyidae indet.

CTENODACTYLIDAE Indet.; cited by Shevyreva, pers. com., 1981

CYLINDRODONTIDAE Indet.; cited by Shevyreva, pers. com., 1981

CRICETIDAE Indet.; cited by Shevyreva, pers. com., 1981

DIPODIDAE Indet.; cited by Shevyreva, pers. com., 1981, as Zapodidae indet.

EOMYIDAE Indet.; cited by Shevyreva, pers. com., 1981

PERISSODACTYLA

BRONTOTHERIIDAE Indet., cited by Yanovskaya, 1980 (cited at Bulkair by Gabunia, 1982)

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Brachyodus*[76] sp.; cited by Gabunia, 1977
— Anthracotheriidae Indet.; cited by Gabunia, pers. com., 1981

LEPTOMERYCIDAE — *Archaeomeryx* sp.; cited by Gabunia, 1977

Locality unknown **early? Oligocene**

PERISSODACTYLA

AMYNODONTIDAE — *Cadurcotherium tuskabakensis* (Biryukov, 1963) Wall, 1982b
(= *Amynodon tuskabakensis* Biryukov, 1963)
(= *Hypsamynodon tuskabakensis* (Biryukov, 1963) Belyaeyva, 1971)

75 Rozovyy Valun = rose colored erratic boulder.
76 *Brachyodus* is generally considered a Miocene form; its presence here would be anomalous.

Source : MNHN, Paris

U.S.S.R.
KAZAKH S.S.R.
Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Kuto Svita **early Oligocene**

Localities: Areal Site XII, Tuzkabak Lake at Chakel'mes Mountain; Areal Site VI, Kiin-Kerish Mountain; Chernyy Irtysh River (Parom); Ashutas Mountain; Areal Site X, between the Kusto and Kyzylkain Rivers (Lysaya Sopka); Dzhamangora River (Tyubeteyka, Blizhnyaya Dvugorbaya Sopka)

The Kusto Svita is among those in the Zaysan Basin that have yielded abundant fossil vertebrates; it is the fourth in richness, coming after the Obayla and the lower and upper parts of the Aksyir Svita. The first finds of mammals of this level were made on the Kusto River in the 1950's by K. V. Kurdyukov and M. M. Smelovska. Some of the material was identified by Belyayeva and subsequently published by Vasilenko (1961). Later, many localities were discovered, among which are those at Tuzkabak Lake, at Kiin-Kerish Mountain, and on the Chernyy Irtysh, Kusto and Dzhamangora Rivers.

In the northwestern part of a small basin situated north of Chakel'mes Mountain and occupied by Tuzkabak Lake, the Kusto Svita overlies the Aksyir and underlies the Buran Svitas (both unconformably), with a gentle dip and a thickness of about 30 m. At 4-5 m above the contact with the Aksyir Svita V. S. Erofeyev, in the 1950's, discovered an important fossil locality that included mammals. The first collections were made by paleontologists from the Academy of Sciences of Kazakhstan (V. S. Bazhanov, M. D. Biryukov and V. V. Kuznetsov).

In the Kusto Svita on Kiin-Kerish Mountain the principal fossil mammal sites are situated on the northwest slopes. This svita is stratigraphically unconformable between the Aksyir below and the Buran Svita above; it is 30-40 m thick and has furnished fossil mammals remains in many levels throughout the section. The greatest concentrations are found in the lower levels of the svita, west of Biryukov Camp, and in its middle part to the north of Shevyreva's camp at Yakor'. In 1953 V. K. Vasilenko was the first to find fossil vertebrates, but again the initial collections were made by the same team of paleontologists from the Academy of Sciences of Kazakhstan cited above.

On the left bank of the Chernyy Irtysh River, above the locality of Parom, the Kusto Svita has a gentle dip and crops out in cliffs reaching a height of 12 m; its total thickness is more than 25 m. In the early 1960's V. I. Zhegallo and B. A. Trofimov found anthracotheriid remains here in the clays of this svita.

Between the Kyzylkain and Kusto Rivers and on the right bank of the latter, the svita varies greatly in dip; its thickness is 45 m and it is unconformable between the Aksyir and Buran Svitas. Fossil mammals were first discovered in the 1950's by Kurdyukov and Smelovskaya in several levels. The richest of these (Lysaya Sopka)[77] were exploited in the 1960's and 70's by Chkhikvadze and Shevyreva near the middle of the svita (at Tyubeteyka[78] and Blizhnyaya Dvugorbaya Sopka[79] and others). Tyubeteyka is situated about 100 m to the east of the Buran Svita locality of Podorozhnik, in the valley of the right tributary to the Dzhamangora River. Blizhnayaya Dvugorbaya Sopka is in Bulkair Valley, about 150 m northwest of Cherep Sopka at which mammalian remains were collected from the middle part of the Aksyir Svita.

On the basis of the presently determined fossil mammals from this svita it appears to be without

77 Lysaya Sopka = bald hillock.
78 Tyubeteyka = a sort of embroidered hat.
79 Blizhnyaya Dvugorbaya Sopka = the near-by two-peaked hillock.

Source : MNHN, Paris

question referable to the Oligocene. All of the genera, with the exception of the surprising presence of *Archaeomeryx*, are from Oligocene faunas, but lacking precise specific identifications it is not possible to say what part of the Oligocene this assemblage represents. We will provisionally use the Soviet attribution of early Oligocene, but the reader should bear in mind that the mammalian evidence is so far inadequate for such precision.

Fauna of the Kusto Svita

(furnished by Dr. Shevyreva, Prof. Gabunia and Dr. Gureyev)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

RODENTIA

CYLINDRODONTIDAE Indet.; cited by Shevyreva, pers. com., 1981

CASTORIDAE Indet.; cited by Shevyreva, pers. com., 1981

CRICETIDAE Indet.; cited by Shevyreva, pers. com., 1981

CTENODACTYLIDAE Indet., cited by Shevyreva, pers. com., 1981, as Chapattimyidae indet.

DIPODIDAE Indet., cited by Shevyreva, pers. com., 1981, as Zapodidae indet.

EOMYIDAE Indet., cited by Shevyreva, pers. com., 1981

PERISSODACTYLA

AMYNODONTIDAE — *Cadurcodon* aff. *zaisanensis* Belyayeva, 1962b; cited by Gabunia, pers. com., 1981

ARTIODACTYLA

ENTELODONTIDAE — *Entelodon* sp.; cited by Gabunia, pers. com., 1981

ANTHRACOTHERIIDAE — *Bothriodon* sp.; cited by Gabunia, 1977
— cf. *Brachyodus*; cited by Gabunia, pers. com., 1981
— Anthracotheriidae Indet.; cited by Gabunia, pers. com., 1981

LEPTOMERYCIDAE — *Archaeomeryx* sp.; cited by Gabunia, pers. com., 1981
— cf. *Miomeryx* sp.; cited by Gabunia, pers. com., 1981
— *Gobiomeryx dubius* Trofimov, 1957; cited by Musakulova, 1963

CERVIDAE — cf. *Eumeryx* sp.; cited by Gabunia, pers. com., 1981

EARLY OLIGOCENE

Composite List

(**Bai**: Baishuicun; **BS**: Baron Sog; **Cai**: Caijiachong; **Cgb**: Chaganbulage; **Erg**: Ergilin-Dzo; **GT**: Gua-Teg; **Hm**: Hami; **Iwk**: Iwaki; **Kd**: Khoer-Dzan; **Ks**: Kusto; **Ksh**: Kushiro-cho; **Lan**: Lantian; **Lop**: Luoping; **Mak**: Middle Aksyir; **Nn**: Nanning; **Shin**: Shinao; **Tsy**: Taoshuyuanzi; **Uak**: Upper Aksyir; **Ug**: Ulan Gochu; **Ur**: Urtyn Obo; **Xia**: Xiaotun. Houldjin, Gongkang and Aksoran not included)

MARSUPIALIA

Uak DIDELPHIDAE Indet.

INSECTIVORA

ERINACEIDAE

Erg — *Ictopidium*? sp.
Erg — *Palaeoscaptor*? sp.

SORICIDAE

Erg — Soricinae indet.
Cai, Ks, Uak — Insectivora indet.

Source : MNHN, Paris

CHIROPTERA
Cai — Vespertilionoidea indet.

Cai PRIMATES? Indet.

LAGOMORPHA

LEPORIDAE
Ug — *Gobiolagus andrewsi*
Ur — *Gobiolagus? major*

OCHOTONIDAE
Erg — *Desmatolagus robustus*
Ug — *Procaprolagus vetustus*
Erg, Cgb, Cai, Lan — Lagomorpha indet.

RODENTIA

PARAMYIDAE
Ug — *Hulgana ertnia*
Ug, Uak — Paramyidae? indet.

CYLINDRODONTIDAE
Ug — *Ardynomus* sp.
Erg — *Ardynomus olseni*
Erg — *Ardynomus? vinogradovi*
Erg — *Morosomys silentiumis*
Ks, Uak —Cylindrodontidae indet.
Ks CASTORIDAE indet.

CRICETIDAE
Erg, Cai — *Eucricetodon* sp.
Ks, Uak — Cricetidae indet.

CTENODACTYLIDAE
Cai — *Karakoromys* sp.
Cai — *Dianomys obscuratus*
Cai — *Dianomys qujingensis*
Ks, Uak — Ctenodactylidae indet.

DIPODIDAE
Cai — *Parasminthus* sp.
Ks, Uak — Dipodidae indet.
Ks, Uak EOMYIDAE indet.
Cgb Rodentia indet.

ANAGALIDA

ANAGALIDAE
Ug — *Anagale gobiensis*

CARNIVORA

CANIDAE
Erg — *Cynodictis?* sp.

FELIDAE
Kd — *Nimravus mongoliensis*

CREODONTA

HYAENODONTIDAE
Erg — *Hyaenodon eminus*
Kd — *Hyaenodon gigas*
Erg — *Hyaenodon dubius*
Kd — *Hyaenodon incertus*
Erg, Kd — *Hyaenodon* sp.
Erg — *Pterodon mongoliensis*
Kd — *Pterodon exploratus*
Kd — *Pterodon* sp.

Source : MNHN, Paris

CONDYLARTHRA

MESONYCHIDAE

Ug — *Mongolestes hadrodens*
Cgb — *Harpagolestes*? *alxaensis*
Ur, Kd — Mesonychidae indet.

PERISSODACTYLA

BRONTOTHERIIDAE

Ug — *Metatitan progressus*
Ug — *Metatitan primus* (stratigraphic position uncertain)
Erg, Kd — *Metatitan relictus*
Erg, Ur — *Parabrontops gobiensis*
Hm — *Parabrontops* sp.
Erg — *Protembolotherium efremovi*
Erg — *Titanodectes ingens*?
Ug — *Embolotherium loucksii*
Erg — *Embolotherium ergilense*
Ug, Cgb — *Embolotherium*? *grangeri*
Kd — *Embolotherium insigne*
Erg, Kd, Ug — *Embolotherium andrewsi*
BS — *Embolotherium ultimum*
Kd, Erg — *Embolotherium* sp.
Erg — *Epimanteoceras robustum*
Shin — *Pygmaetitan panxianensis*
Uak, Mak, Kd, Cai — Brontotheriidae indet.

EQUIDAE

Shin — *Qianohippus magicus*

CHALICOTHERIIDAE

Erg, BS, Kd — *Schizotherium avitum*
Ur — *Schizotherium* cf. *avitum*.
BS — *Schizotherium* sp.

DEPERETELLIDAE

Kd, Cgb — *Teleolophus magnus*
Cgb — *Teleolophus* cf. *medius*

HELALETIDAE

Erg, Kd — *Colodon inceptus*
Ksh — *Colodon*? *kushiroensis*
Erg — *Colodon* sp.

LOPHIALETIDAE

Lan — *Simplaletes xianensis*

HYRACODONTIDAE

Erg, Kd, Ur, GT — *Ardynia praecox*
Cai, Kd — *Prohyracodon* sp.
Erg — *Forstercooperia ergiliinensis*
Ur — *Urtinotherium incisivum*
Kd — *Indricotherium parvum*
Lop, Cai — *Indricotherium intermedium*
Cai — *Indricotherium qujingensis*
Cai — *Indricotherium* sp.
Cai — Caenopinae indet.
Shin, Xia — Hyracodontidae indet.

RHINOCEROTIDAE

Erg — *Ronzotherium brevirostre*
Cai — Rhinocerotidae indet.

Source : MNHN, Paris

AMYNODONTIDAE

Erg	— *Caenolophus promissus*
Erg, Tsy, Ur, Cai, Kd, GT	— *Cadurcodon ardynensis*
Ks	— *Cadurcodon* aff. *zaisanensis*
Ur, Ug, Cai, GT	— *Cadurcodon* sp.
Erg, Kd	— *Gigantamynodon cessator*
Kd, Cai	— *Gigantamynodon* sp.
Cai	— *Gigantamynodon giganteus*
Cai	— *Gigantamynodon* cf. *giganteus*
Xia	— cf. *Gigantamynodon giganteus*
Erg	— *Cadurcotherium progressus*
Uak	— *Cadurcotherium tuskabakensis*
Erg	— *Sharamynodon mongoliensis*
Ur, Cgb	— *Amynodon alxaensis*
Kd	— *Amynodon giganteus*
Ur	— *Amynodontopsis parvidens*
Ug	— *Amynodontopsis* sp.
Cgb, Lan	— *Sianodon* sp.
Lan	— *Sianodon bahoensis*
Ug	— *Zaisanamynodon*? sp.
Cgb	— *Paracadurcodon suhaituensis*
Cai	— cf. *Metamynodon* sp.
Ug, Cgb	— Amynodontidae indet.

ARTIODACTYLA

ENTELODONTIDAE

Erg	— *Entelodon gobiensis*
Kd	— *Entelodon orientalis*
Iwk, Ur, Cai, Ks	— *Entelodon* sp.
Erg	— *Entelodon*? sp.
Kd	— *Eoentelodon trofimovi*
Cgb	— Entelodontidae indet.

ANTHRACOTHERIIDAE

Ks, Erg, Uak	— *Brachyodus*? sp.
Nn	— *Heothema nanningensis*
Nn	— *Heothema youngi*
Bai, Xia	— *Bothriogenys hui*
Cai	— *Bothriodon chowi*
Kd, Ks	— *Bothriodon* sp.
Ks, Uak	— Anthracotheriidae indet.

LEPTOMERYCIDAE

Erg	— *Miomeryx altaicus*
Erg, Cai	— *Miomeryx* sp.
Ks	— cf. *Miomeryx* sp.
Ks, Uak	— *Archaeomeryx* sp.
Erg, Ks	— *Gobiomeryx dubius*

CERVIDAE

Erg	— *Eumeryx* sp.
Ks	— cf. *Eumeryx* sp.
Cgb	— Cervidae indet.

GELOCIDAE

Erg	— *Lophiomeryx angarae*
Erg	— *Lophiomeryx gobiae*
Shin	— *Lophiomeryx shinaoensis*
Shin	— *Lophiomeryx gracilis*
Shin	— *Lophiomeryx gracilis*?
Kd, Cai	— *Lophiomeryx* sp.

Source : MNHN, Paris

Cai — cf. *Indomeryx* sp.
Cgb — Bovidae indet.

ARTIODACTYLA

FAMILY Indet.

Lan — *Lantianius xiehuensis*
Xia — Artiodactyla indet.

ORDER INDET.

DIDYMOCONIDAE

Erg — *Ardynictis furunculus*

Source : MNHN, Paris

Lat. 39° 40′ 7″ N
Long. 105° 45′ E

Fig. 2, n° 28

CHINA
NEI MONGOL AUTONOMOUS REGION
Alashan Zuoqi District
Jilantai Basin

unnamed formation **middle Oligocene**
Locality: Ulantatal

In 1978 a field team from the IVPP made important collections of Oligocene mammals in Alashan Zuoqi[1], western Inner Mongolia. The Ulantatal[2] locality is named for the small gully in the Jilantai[3] Basin in which the fossils were found. Sediments of Pliocene and Pleistocene age are also found here.

The Oligocene beds are about 20 m thick and are revealed in the sides of mesas. They consist mainly of light reddish purple and sandy yellowish mudstone and argillaceous silstone with one or two intercalated beds of sandstone and gravel. Some levels also contain gypsum and conglomerate. Lithology is somewhat similar to that of the Qingshuiying Formation in Ningxia. The beds are overlain by Neogene sand and gravel, but the bottom of the formation is not visible.

The fauna correlates well with that of Shand-Gol and can be considered middle Oligocene in age, although *Ardynomys* is a relict from the early Oligocene and *Sinolagomys major*, cf. *Sinolagomys kansuensis* and cf. *Parasminthus tangingoli* anticipate late Oligocene assemblages.

Fauna of the unnamed formation at Ulantatal

(all cited by Huang, 1982, V.P. (4); exceptions are indicated)

INSECTIVORA
ERINACEIDAE
— *Amphechinus rectus*[4] Matthew & Granger, 1924b
— *Amphechinus* cf. *rectus* Matthew & Granger, 1924b; cited by Huang, 1984, V.P. (4)
— *Palaeoscaptor acridens* Matthew & Granger, 1924b; cited by Huang, 1984, V.P. (4)

LAGOMORPHA
LEPORIDAE
— *Ordolagus* sp.
OCHOTONIDAE
— *Sinolagomys major* Bohlin, 1937
— cf. *Sinolagomys kansuensis* Bohlin, 1937
— *Bohlinotona*? spp.

RODENTIA
TSAGANOMYIDAE[5]
— *Cyclomylus lohensis* Matthew & Granger, 1923c
— cf. *Cyclomylus minutus* Kowalski, 1974

1 Alashan Zuoqi (= Alxa Zuoqi) = Left Alxa County.
2 Ulantatal = red stream.
3 Jilantai = there where there are 60.
4 The attribution of the species *rectus* to *Amphechinus* has been usually questioned. In his analysis of 1984, Butler referred *rectus* without doubt.
5 *Fide* Patterson & Wood 1982.

Source : MNHN, Paris

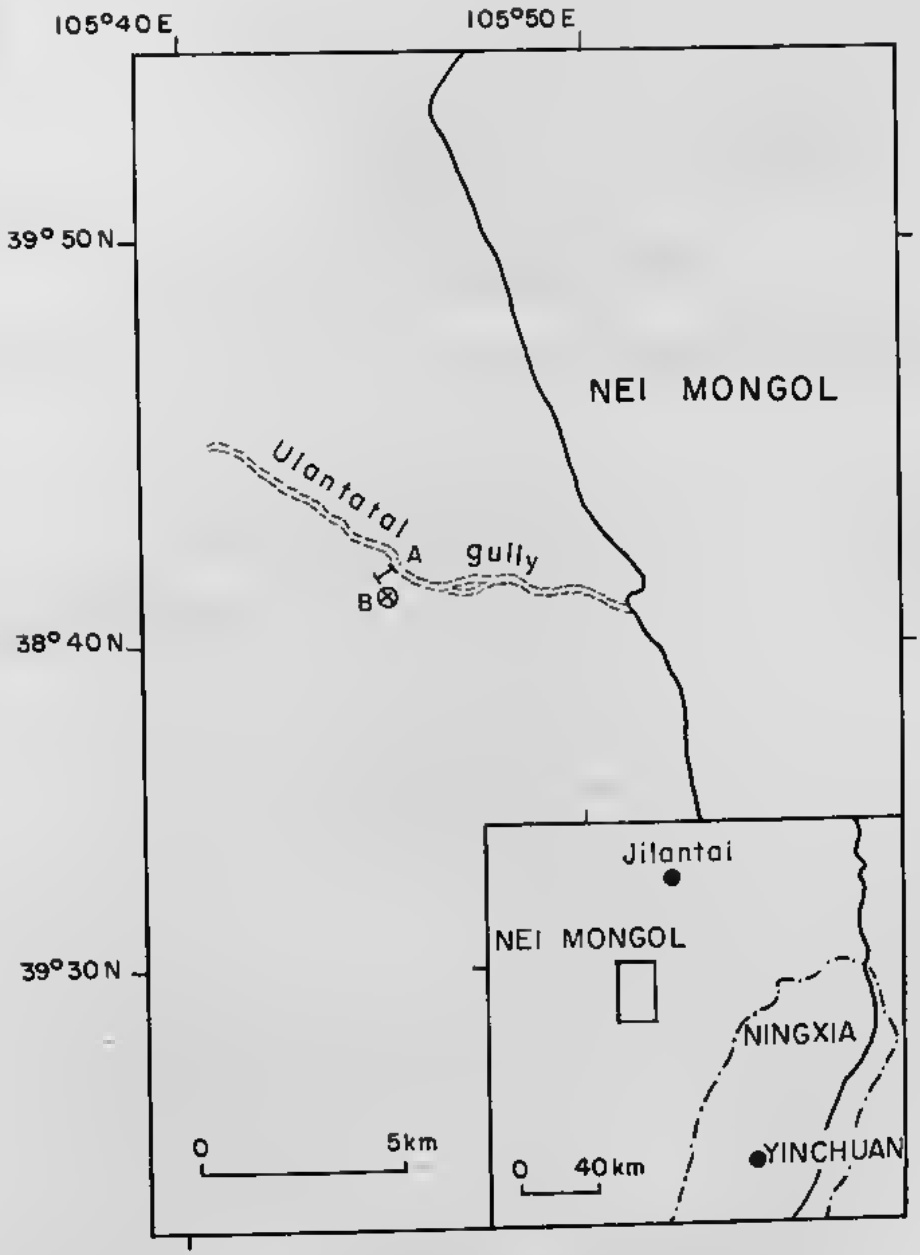


FIG. 164. — Detailed and general sketch maps showing the situation of the fossil mammal locality of Ulantatal. Modified from Huang, 1982.

Source : MNHN, Paris

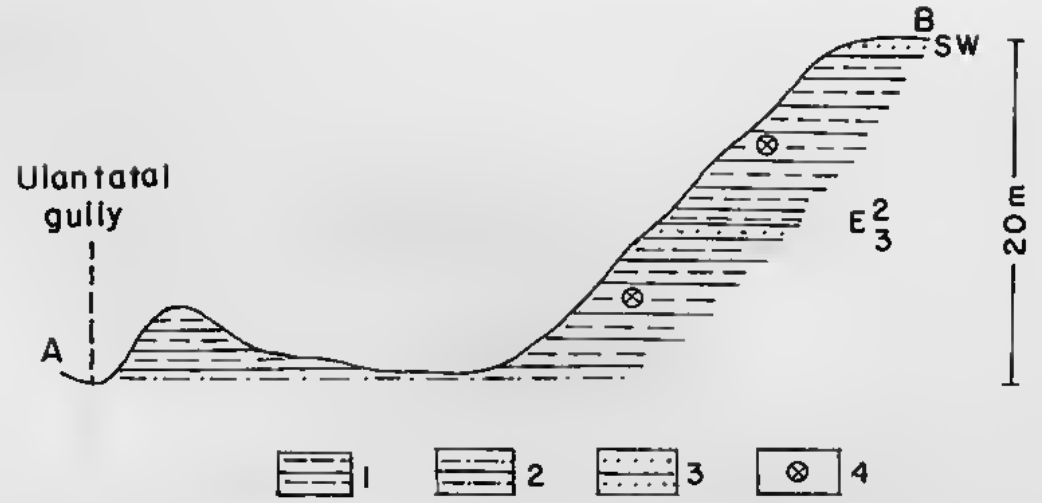


FIG. 165. — Section through the middle Oligocene locality of Ulantatal, Alashan Zuoqi, Nei Mongol. Modified from Huang, 1982.

CYLINDRODONTIDAE — *Ardynomys* sp.

APLODONTIDAE? — *Selenomys mimicus* Matthew & Granger, 1923d

CRICETIDAE Indet.

CTENODACTYLIDAE
— *Tataromys ulantatalensis* Huang, 1985a, V.P. (1)
(= *Tataromys plicidens* Matthew & Granger, 1923d; cited by Huang, 1982, V.P. (4)
— *Tataromys* cf. *sigmodon* Matthew & Granger, 1923d; cited by Huang, 1985a, V.P. (1)
(= *Tararomys sigmodon* Matthew & Granger, 1923d; cited by Huang, 1982, V.P. (4))
— *Tataromys bohlini* Huang, 1985a, V.P. (1)
(= *Tataromys grangeri* Bohlin, 1946; cited by Huang, 1982, V.P. (4))
— *Leptotataromys gracilidens* Bohlin, 1946; cited by Huang, 1985a, V.P. (1)
— *Leptotataromys* cf. *gracilidens* Bohlin, 1946; cited by Huang, 1985a, V.P. (1)
(= *Tataromys* spp.; cited by Huang, 1982, V.P. (4))
— *Leptotataromys minor* Huang, 1985a, V.P. (1)
(= *Tataromys* spp.; cited by Huang, 1982, V.P. (4))
— *Karakoromys decessus*? Matthew & Granger, 1923d; cited by Huang, 1985a, V.P. (1)
— (= *Tataromys* spp.; cited by Huang, 1982, V.P. (4))

DIPODIDAE — cf. *Parasminthus tangingoli* Bohlin, 1946

CARNIVORA

CANIDAE — *Cynodictis*? sp.

MUSTELIDAE — *Palaeogale ulysses* Matthew & Granger, 1924a) Simpson, 1946
(= *Bunaelurus ulysses* Matthew & Granger, 1924a)
(= *Bunaelurus parvulus* Matthew & Granger, 1924a, *in* Simpson, 1946)
(= *Palaeogale parvula* Matthew & Granger, 1942a, *in* de Bonis, 1981; considered a valid species by Mellett, 1968 and by Huang, 1982)

Source : MNHN, Paris

CARNIVORA Indet.

CREODONTA

HYAENODONTIDAE — *Hyaenodon*? sp.

PERISSODACTYLA

RHINOCEROTIDAE — *Aceratherium* sp.

AMYNODONTIDAE — *Cadurcodon* sp.

ARTIODACTYLA

CERVIDAE — *Eumeryx culminus* Matthew & Granger, 1924b; cited by Huang, 1985b V.P. (2)
(= *Eumeryx* sp.; cited by Huang, 1982, V.P. (4))

RUMINANTIA Indet. — *Palaeohypsodontus* cf. *asiaticus* Trofimov, 1958; cited by Huang, 1985b, V.P. (2)
(= *Palaeohypsodontus* sp.; cited by Huang, 1982, V.P. (4))
— *Hanhaicerus qii* Huang, 1985b, V.P. (2)

ORDER Indet.

DIDYMOCONIDAE — cf. *Didymoconus berkeyi* Matthew & Granger, 1924a
— *Didymoconus* sp.

ORDER & FAMILY Indet.

Lat. 39° 50′-40° 30′ N
Long. 106° 30′-107° 00′ E

Fig. 2, n° 30

CHINA

NEI MONGOL AUTONOMOUS REGION

Qianlishan District

Wulanbulage Fm. **middle Oligocene**

Locality: Yikebulage Dadui

Qianlishan[6] Hill, the northermost part of the Zhuozishan Mountains, is located on the northwestern border of Ordos. Administratively, it represents the western boundary of the Yik Ju Meng[7] of Nei Mongol. On the western piedmont of the Qianlishan and the area farther north of it along the east bank of the Huanghe, a thick series of sporadically outcropping Tertiary fossil mammal-bearing sediments are developped. One of the two Ordos Oligocene localities investigated by Teilhard de Chardin is situated in the north of this district. The area west of Qianlishan, i.e. Yikebulage Dadui[8], however, had never been investigated by vertebrate paleontologists until 1978, when an IVPP team was sent there to survey in cooperation with the local geological brigade; collecting continued in 1979.

The Tertiary sediments in the Yikebulage Dadui area are mainly red in color. They may be divided into four parts:

4) upper part, unnamed formation and possibly Miocene in age, comprised of light orange and yellow conglomeratic sandstone containing lenses of sandy mudstone; thickness 72 m.
3) middle part: Yikebulage Formation.
2) lower part: Wulanbulage Formation.

6 Qianlishan (Qian = thousand; li = ½ km; shan = hill or mountain).
7 Yik Ju Meng (Yik = place name; Ju = big lamasery; Meng = administrative unit which controls several Qi (or counties).
8 Yikebukage Dadui (Yikebulage = great springs; Dadui = a production brigade of a rural people's commune).

Source : MNHN, Paris

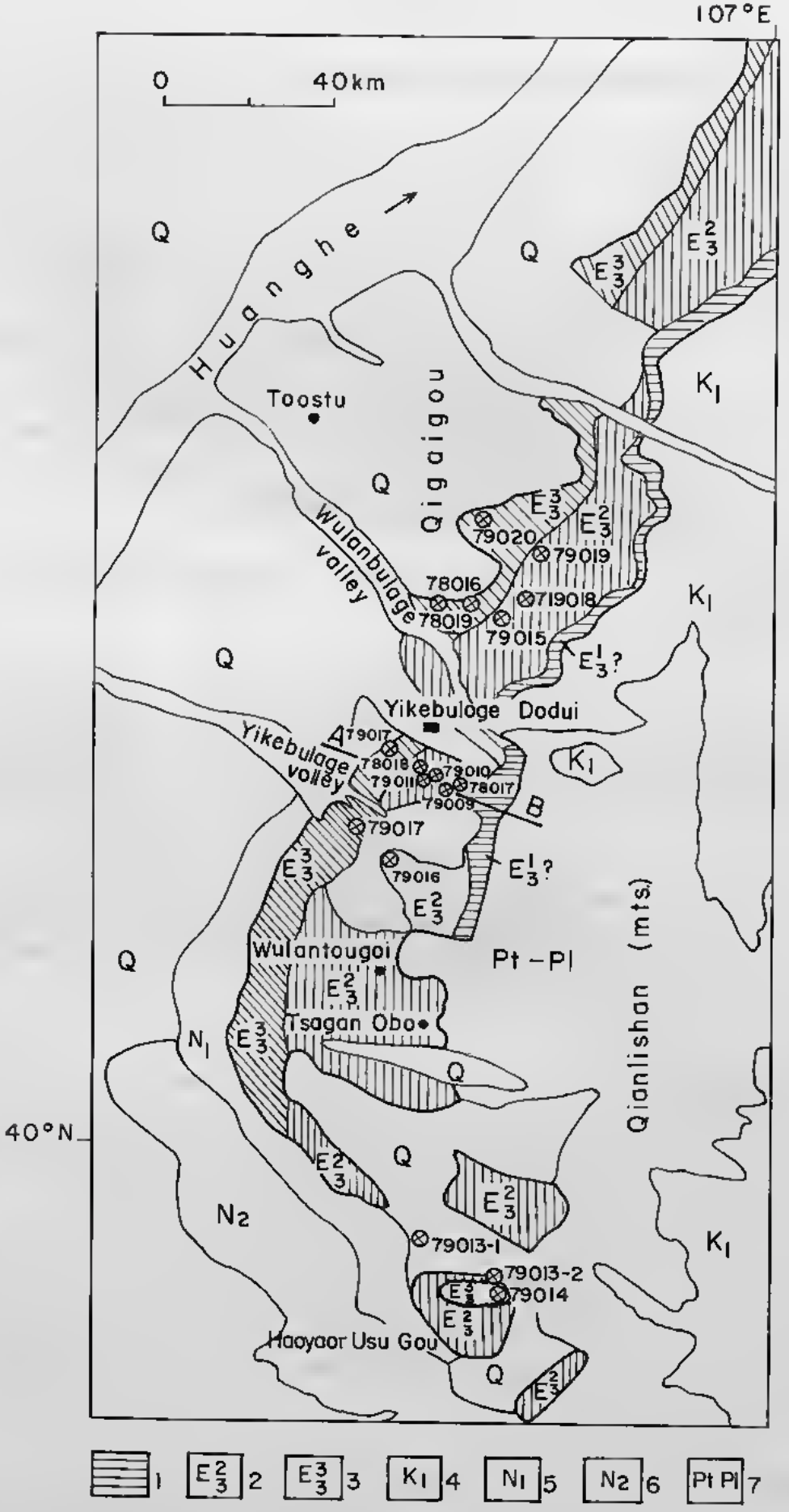


FIG. 166. — Outcrop map of the Oligocene sediments in the region around Yikebulage and Wulanbulage, Qianlishan District, Nei Mongol. **1.** unnamed formation of possibly early Oligocene age; **2.** middle Oligocene Wulanbulage Fm.; **3.** late Oligocene Yikebulage Fm.; **4.** early Cretaceous Zhidan Group; **5.** Miocene; **6.** Pliocene; **7.** Proterozoic to Paleozoic rocks. Modified from Wang *et al.*, 1981.

Source : MNHN, Paris

1) basal part (unnamed formation) possibly early Oligocene in age; 25 m in thickness, and consists of grayish white, brick red and brownish red sandy mudstones, intercalated with 3-5 layers of marls. It unconformably overlies the early Cretaceous Zhidan Group or older rocks.

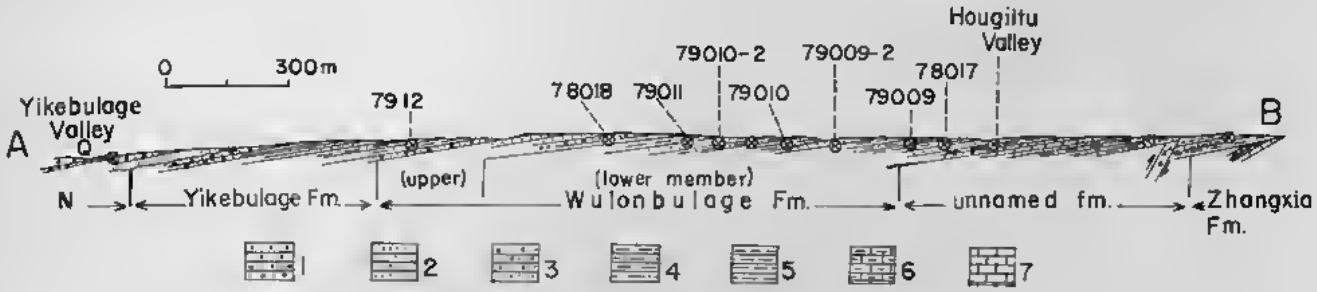


FIG. 167. — Cross section taken from the Yikebulage Valley, Qianlishan District, Nei Mongol, eastward through the Hougiltu Valley showing the development of the Oligocene sediments; a possibly early Oligocene unnamed formation, the middle Oligocene Wulanbulage Fm. and the late Oligocene Yikebulage Fm. 1. sand and gravel; 2. sandstone; 3. siltstone with concretions; 4. silty mudstones; 5. mudstone; 6. marl; 7. limestone. Modified from Wang *et al.*, 1981.

The Wulanbulage Formation unconformably overlies the basal part. It was divided into two members. The lower member is made up of dark red, purplish red mudstone and argillaceous siltstone, sandy and silty mudstone, containing orange sandstone; thickness 72 m. It is conformably overlain by the late Oligocene Yikebulage Formation.

The preliminary fauna list shows that ten of the 19 taxa, i.e. *Desmatolagus gobiensis*, *Karakoromys decessus*, *Parasminthus tangingoli*, *Cricetops dormitor*, *Cyclomylus lohensis*, *C. minutus*, *Tataromys sigmodon*, *Schizotherium* sp., *Eumeryx* sp., and *Tsaganomys* sp., are also known from the Shand-Gol Svita, Mongolia. The correlation between them is thus evident. As is the case in the Shand-Gol Svita, the lower member of the Wulanbulage Formation has yielded such earlier forms as *Cadurcodon ardynense* and *Lophiomeryx gobiae*, which are so far known only in the early Oligocene Ergilin-Dzo Svita or its equivalents; and the upper member contains late Oligocene, or even later, forms. Therefore, it seems that the age of the Wulanbulage Formation, like that of the Shand-Gol Svita, covers a rather long time range. The main part of it may be middle Oligocene and the basal part, under the layer 10, may even be early Oligocene.

Fauna of the Wulanbulage Fm.
(upper member)

(all cited by Wang *et al.*, 1981, V.P. (1))

INSECTIVORA Indet.

LAGOMORPHA

OCHOTONIDAE — *Desmatolagus gobiensis* Matthew & Granger, 1923d

RODENTIA

TSAGANOMYIDAE — *Cyclomylus lobensis* Matthew & Granger, 1923c
— *Tsaganomys* sp.

CRICETIDAE — *Cricetops dormitor* Matthew & Granger, 1923d

CTENODACTYLIDAE — *Tataromys sigmodon* Matthew & Granger, 1923d

DIPODIDAE — *Parasminthus asiaecentralis* Bohlin, 1946

Source : MNHN, Paris

CARNIVORA Indet.

PERISSODACTYLA

CHALICOTHERIIDAE — *Schizotherium* sp.
— Chalicotheriidae indet.

HYRACODONTIDAE — *Paraceratherium* n. sp.
— *Aprotodon* n. sp.

ARTIODACTYLA

CERVIDAE — *Eumeryx* sp.

BOVIDAE (?) — Indet.

Fauna of Wulanbulage Fm.
(lower member)

(all cited by Wang *et al.*, 1981, V.P. (1))

LAGOMORPHA

LEPORIDAE Indet.

OCHOTONIDAE — *Desmatolagus gobiensis* Matthew & Granger, 1923d

RODENTIA

TSAGANOMYIDAE — *Cyclomylus lohensis* Matthew & Granger, 1923c
— *Cyclomylus minutus* Kowalski, 1974
— *Cyclomylus* sp.

CTENODACTYLIDAE — *Tataromys* sp.
— *Karakoromys decessus* Matthew & Granger, 1923d

DIPODIDAE — *Parasminthus tangingoli* Bohlin, 1946

CARNIVORA

MIACIDAE Indet.

CARNIVORA Indet.

CREODONTA

HYAENODONTIDAE — *Hyaenodon*? sp.

PERISSODACTYLA

AMYNODONTIDAE — *Cadurcodon ardynensis* (Osborn, 1923c), Kretzoi, 1942
(= *Cadurcotherium ardynense* Osborn, 1923c)

ARTIODACTYLA

CERVIDAE — *Eumeryx* sp.

GELOCIDAE — *Lophiomeryx gobiae* Matthew & Granger, 1925c
— *Lophiomeryx* sp.

TRAGULIDAE Indet.

ARTIODACTYLA Indet.

Source : MNHN, Paris

Lat. 40° 18′ N
Long. 107° 00′ E
(Dengkou City)

Fig. 2, n° 30

CHINA

NEI MONGOL AUTONOMOUS REGION

QIANLISHAN DISTRICT

"Sediments of Saint-Jacques" (= Wulanbulage Fm.?) **middle Oligocene**

Locality: Saint-Jacques

During the summer of 1922, Teilhard de Chardin and Licent were sent by the French National Museum of Natural History and the Ministry of Public Instruction to the region of Ordos to exploit Quaternary deposits already known for their fossil content. Ordos is that territory within the great northward loop of the Huanghe (Yellow River); their objective was situated in the SE part of the region. The presence of bandits and an unusual drought

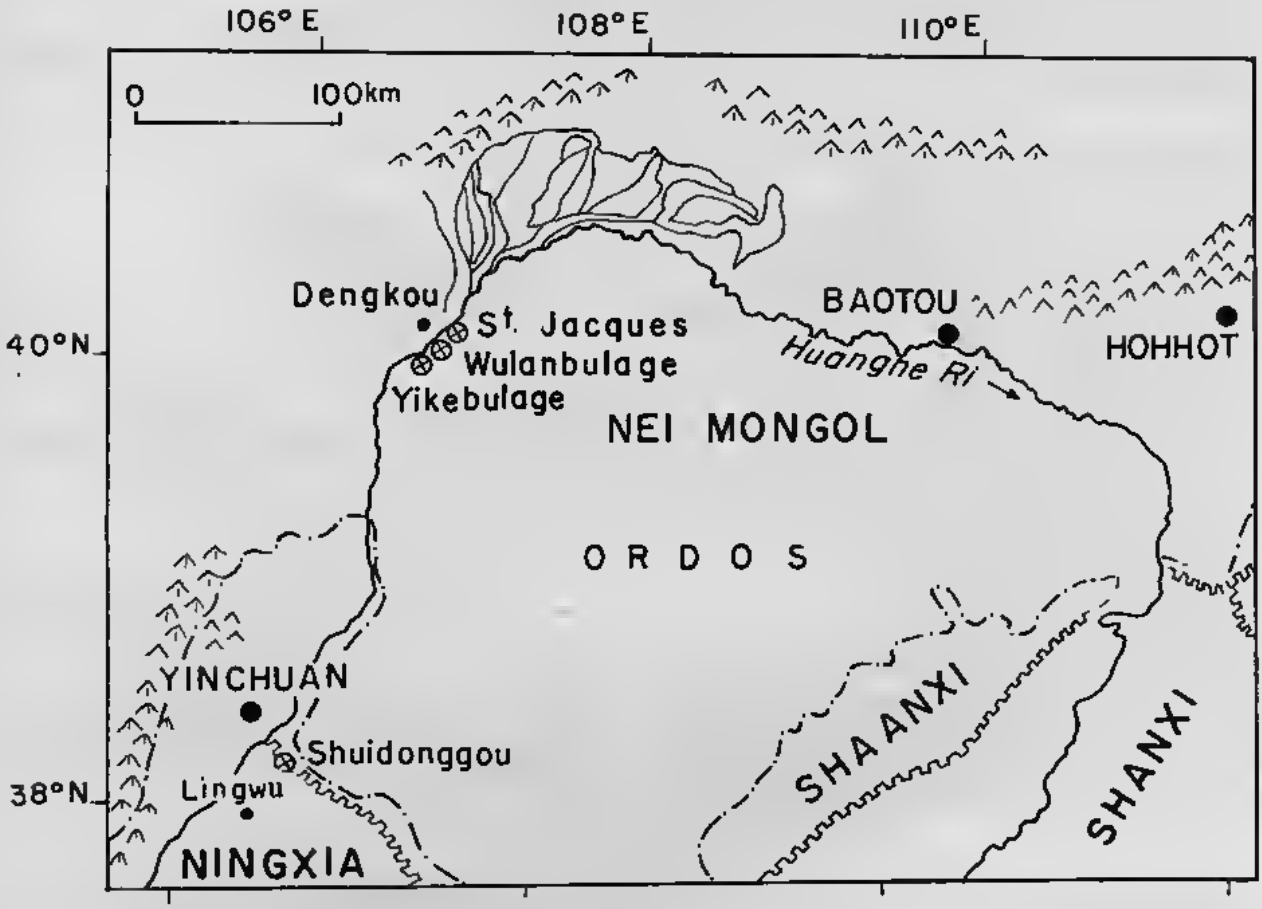


FIG. 168. — Map of the Ordos region of Nei Mongol showing the position of the Oligocene localities of St.-Jacques, Wulanbulage, Yikebulage and Shuidonggou. Redrawn from a map provided by Zhai R.-j.

Source : MNHN, Paris

obliged them to circle westward from "Ville Bleue" (= Hohhot[9]), following the course of the river upstream, which resulted in the discovery of an Oligocene fauna.

The name of Saint-Jacques is derived from a French Catholic mission on the west bank of the Huanghe; it was there that Teilhard de Chardin and Licent learned of the presence of fossils in the badlands across the river and the fossil site (on the east bank) was named in reference to the mission. The local name of San tao ho was variably used as indicating the mission or a large region around it.

The locality was essentially lost for many years, although the joint Chinese-Soviet Expedition of 1959 spent a brief time there. The mission of Saint-Jacques (in the village of Toukoutang) was cited as part of the city of Shanshenggong (west bank of the Huanghe). The fossil locality, on the east bank, yielded indricotheres, carnivores and rodents. No further Tertiary paleontological work was done in the area until 1978 and 1979 when the IVPP sent three parties to collaborate with the local surveying brigade that had discovered fossils (in 1978) in the red beds. They visited Teilhard de Chardin's Saint- Jacques area but failed to make clear where the locality was. Recent research has shown that the mission is now situated in the southern part of the city of Dengkou[10] (not Tangkou, a different city which is now called Bayin Muren).

Teilhard de Chardin and Licent collected in an erosional embayment in the cliffs along the east bank of the Huanghe, directly opposite the mission, that the Mongols called Ula chu ho la. On the north slopes of this amphitheatre they found two levels of fluviatile white and reddish sands, separated by about 20 m of red argilaceous sands. These levels, 4 to 5 m thick, become indurated at their base. A third fossiliferous level was discovered low in the section, but isolated from the rest; it is capped by a hard limestone containing large planorbid gastropods. Overlying the top fluviatile sand is a sequence of red argillaceous sands containing irregular bands of limestone, then a conglomeratic level, with a thick bed of Quaternary conglomerate forming the top.

The detailed stratigraphic work and collecting done by the IVPP crews south of Dengkou

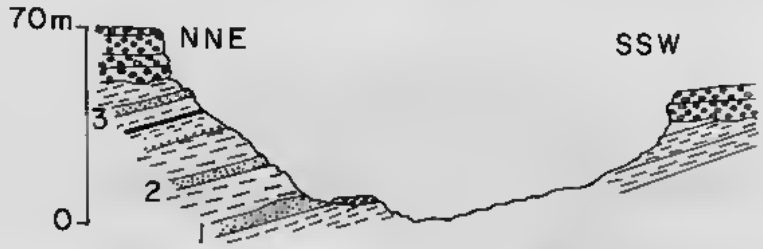


FIG. 169. Cross section of the valley at the St.-Jacques fossil mammal locality, Nei Mongol, showing the inclined Oligocene beds with overlying horizontal Quaternary gravels. 1 and 2, the fossiliferous sands containing the indricothere fauna; 3, bed of rolled concretions. Modified from Teilhard de Chardin & Licent, 1924.

confirmed the presence of at least two fossiliferous levels in the region. But, contrary to the opinion of Teilhard de Chardin who considered the fauna of the different beds homogeneous, Wang *et al.*, 1981, found two different ages represented. The sediments of the upper fossiliferous level were named the Yikebulage Formation (late Oligocene) and the lower one the Wulanbulage Formation (middle Oligocene); it is probable that most of Teilhard de Chardin's fauna came from the latter.

Correlation of the species in the Saint-Jacques fauna indicates a considerably closer relationship to the Shand-Gol fauna (middle Oligocene) than to the Taben Buluk fauna (late Oligocene).

9 Hohhot (= Huhehot): hot = city, but hoh can mean either blue or green. The latter could be valid because of the vegetation present which contrasts with the desert-like surrounding country; Teilhard de Chardin (who passed there) translated the name as blue.

10 Bayan Gaole (Mongol name) (= Bayan Gol) = rich stream; Dengkou (Chinese name) (= Sanshenggong = Sanshenkong = Shan Sun Gon).

Source : MNHN, Paris

The Saint-Jacques Fauna

INSECTIVORA

ERINACEIDAE

— *Amphechinus rectus* (Matthew & Granger, 1924b) Butler, 1984
(= *Amphechinus? rectus* (Matthew & Granger, 1924b) Butler, 1948)
(= *Palaeoscaptor rectus* Matthew & Granger, 1924b)
(= *Palaeoscaptor acridens* Matthew & Granger, 1924b; cited by Teilhard, 1926; misidentification noted by Butler, 1984)

LAGOMORPHA

LEPORIDAE

— *Ordolagus teilhardi* Burke, 1941) de Muizon, 1977
(= *Gobiolagus? teilhardi* Burke, 1941)
(= Duplicidenté indéterminé; cited by Teilhard de Chardin, 1926)

OCHOTONIDAE

— *Bohlinotona pusillus* (Teilhard de Chardin, 1926) de Muizon, 1977
(= *Desmatolagus pusillus* Teilhard de Chardin, 1926)
— *Procaprolagus radicidens* (Teilhard de Chardin, 1926) de Muizon, 1977
(= *Desmatolagus radicidens* Teilhard de Chardin, 1926)
— "*Desmatolagus*" *robustus* (Matthew & Granger, 1923d) de Muizon, 1977
(= *Desmatolagus robustus* Matthew & Granger, 1923d; cited by Teilhard de Chardin, 1926)
— *Sinolagomus* cf. *major*, 1937; cited by de Muizon, 1977

RODENTIA

TSAGANOMYIDAE

— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Teilhard de Chardin, 1926

CTENODACTYLIDAE

— *Tataromys plicidens* Matthew & Granger, 1923d; cited by Teilhard de Chardin, 1926
— *Tataromys deflexus* Teilhard de Chardin, 1926
— *Karakoromys decessus* Matthew & Granger, 1923d; cited by Shevyreva, 1976
— *Karakoromys*? sp.; cited by Teilhard de Chardin, 1926

CARNIVORA

AMPHICYONIDAE

— *Amphicyon*? sp.; cited by Teilhard de Chardin, 1926

CREODONTA

HYAENODONTIDAE

— *Hyaenodon* sp.; cited by Teilhard de Chardin, 1926
Note: the specimens identified as *Ictitherium* or *Hyaena* by Teilhard de Chardin, 1926, do not belong to the Hyaenidae and should be considered as creodonts; G. Petter, pers. com., 1986.

PERISSODACTYLA

CHALICOTHERIIDAE

— *Schizotherium* cf. *avitum* Matthew & Granger, 1923b; cited by Teilhard de Chardin, 1926[11]

HELALETIDAE

— *Hyrachyus*? sp.; cited by Teilhard de Chardin, 1926

HYRACODONTIDAE

— *Indricotherium transouralicum* Pavlova, 1922; cited by Teilhard de Chardin, 1926
(= *Baluchitherium grangeri* Osborn, 1923a, *in* Gromova, 1959)

11 Coombs (1978) notes that it is unlikely that the species *avitum* is represented by Teilhard de Chardin's material. She suggests that both Chalicotheriinae and Schizotheriinae are present, and considers the material as indeterminate; she acknowledges, however, that Hu's (1959) reference of the mandible to *Schizotherium ordosium* may be correct. No locality data is available for the latter species, beyond the name Hortau, a region that apparently corresponds roughly to that of Ordos.

Source : MNHN, Paris

— *Paraceratherium* sp.; cited by Chiu, 1962, V.P. (1)
(= *Indricotherium* sp. (small); cited by Teilhard de Chardin, 1926)

RHINOCEROTIDAE — *Aceratherium*? sp.; cited by Teilhard de Chardin, 1926

ARTIODACTYLA

CERVIDAE Indet. (2 forms); cited by Teilhard de Chardin, 1926 (teeth)

TRAGULIDAE — "*Eumeryx* cf. *culminis* Matthew & Granger 1924b", or "Forme C" pro parte; cited by Teilhard de Chardin, 1926 (limb bones); identification by H. Thomas, pers. com., 1986

RUMINANTIA Indet., "Forme A"; cited by Teilhard de Chardin, 1926 (limb bones); identification by H. Thomas, pers. com., 1986

PROBOSCIDEA — *Serridentinus*? sp. was cited by Teilhard de Chardin. 1926, but one tooth fragment upon which this identification was based is more probably referred to a hyracodont and the other to a Recent elephant (H. Thomas, 1985)

Lat. 38° 15′ N
Long. 106° 20′ E

Fig. 2, n° 29

CHINA

NINGXIA HUI AUTONOMOUS REGION

(Ningshia)

Lingwu District

unnamed formation **middle Oligocene**

Locality: Shuidonggou [12]

Teilhard de Chardin and Licent, during their expedition of 1922, found that 250 km south of the Saint-Jacques locality, in the SW part of Ordos, beds containing *Indricotherium* reappear. As at Saint-Jacques, the sediments are sandy and mixed with numerous small, rolled calcareous concretions. Most of the fossils also show the results of rolling and wear after fossilization.

The sands are 2 or 3 m thick and are poorly exposed; moreover, little time could be spent in the area.

The new faunal elements discovered are comparable to those from Saint-Jacques and are hence probably contemporaneous.

The fauna of Shuidonggou

RODENTIA

TSAGANOMYIDAE — *Tsaganomys* sp.; cited by Teilhard de Chardin, 1926

PERISSODACTYLA

HYRACODONTIDAE — *Indricotherium transouralicum* Pavlova, 1922
(= *Baluchitherium grangeri* Osborn, 1923a, *in* Gromova, 1959; cited by Teilhard de Chardin, 1926)

— Hyracodontidae indet.; cited by Teilhard de Chardin, 1926

ARTIODACTYLA

CERVIDAE — *Eumeryx* sp.; cited by Teilhard de Chardin, 1926

12 Shuidonggou (= Choei long k'eou = Chouilong-ko).

Source : MNHN, Paris

Lat. 38° 05' N
Long. 106° 20' E
(Lingwu City)

Fig. 2, n° 29

CHINA
NINGXIA HUI AUTONOMOUS REGION
(Ningshia)
Lingwu District

Qingshuiying Fm. **middle Oligocene**
Locality: Qingshuiying

Lingwu[13] County was governed by Gansu Province in the 1950's, but with the creation of the Autonomous Region of Ningxia near the end of that decade, it was included in the territory of the latter administrative region.

Fossil mammal material was collected in Lingwu County in 1955 by a field party from the Northwestern Geological Bureau. IVPP personnel have not visited the area.

The fossils were found in beds of grayish green sandy marl, with numerous gypsum veins, named the Qingshuiying[14] Formation; no thickness was given for this formation and no other stratigraphical data is known. Later, an astragalus of *Schizotherium* was sent to the IVPP but no other information accompanied this specimen. Fragmentary specimens of *Indricotherium* were collected from localities near Qingshui village, from Tongxin[15], Guyuan[16] and Lungte, but they have not been described.

The faunule of Qingshuihing Formation is best correlated with the Shand-Gol fauna of Mongolia.

Both of the localities, Shuidonggou and Qingshuiying, are situated within the circle indicating the former on the map, Fig. 168. They are possibly in the same formation and yield a similar fauna.

Fauna of the Qingshuiying Fm.

RODENTIA
TSAGANOMYIDAE — *Cyclomylus lohensis* Matthew & Granger, 1923c; cited by Hu, 1962, V.P. (2)

PERISSODACTYLA
CHALICOTHERIIDAE — *Schizotherium* sp.; cited by Hu, 1959
HYRACODONTIDAE — *Indricotherium transouralicum* Pavlova, 1922; cited as *Indricotherium grangeri* (Osborn) by Hu, 1962, V.P. (2)
(= *Baluchitherium grangeri* Osborn, 1923a; cited by Young & Chow, 1956)

ARTIODACTYLA
ENTELODONTIDAE — *Entelodon ordosius* (Young & Chow, 1956) Brunet, 1979
(= *Archaeotherium ordosius* Young & Chow, 1956)
CERVIDAE — "*Eumeryx*" sp.; cited by Hu, 1962, V.P. (2)

13 Lingwu = clever military.
14 Qingshuiying (= Tsingshiyin) = clear water camping ground.
15 Tongxin = (Tungsing).
16 Guyuan = (Kuyuan).

Source : MNHN, Paris

Lat. 45° 11′ N
Long. 101° 35′ E
(for Tatal-Gol)

Fig. 1, n° 23, 24

MONGOLIA
OBOR-KHANGAY PROVINCE
Valley of Lakes Depression

Shand-Gol Svita **middle Oligocene**

Localities: Tatal-Gol, Shand-Gol (Hsanda Gol)

The Oligocene exposures in the basin of Lake Tsagan-Nur[17], in the eastern part of the Valley of Lakes, were discovered by the American Museum Central Asiatic Expedition of 1922. Much of the American collecting was done in the area around their camp at Loh[18]. Another major site is in the region of Tatal-Gol[19] sayr, about 15 km west of Shand-Gol[20] sayr. which was also exploited in 1948-1949 by Soviet expeditions, and by the Polish-Mongolian one of 1964. Other work was done here by Dashzeveg, by Devyatkin, by Goroshko and Kurochkin in the 1970's, and Zhegallo and Dmitriyeva in 1978.

Berkey & Granger (1923) gave the name Hsanda Gol, from the dry, sandy stream bed that cuts through a major part of the section, to the formation that has yielded the rich and varied fauna. The latter assemblage was described in a series of preliminary papers by Matthew and Granger in 1923 and 1924 on the basis of the collections in 1922. A more extensive collection was made in 1925, but it was essentially unstudied before the investigations of Mellett (1968). The short paper summarizing his results was principally concerned with a revised faunal list. In this article he also cited the eight localities (with the taxa found in each) that contributed the material constituting the American Museum collections. Since then more than 30 producing localities have been made in the Shand-Gol sediments.

The concept of the Hsanda Gol Formation, established by the American Museum Expedition members, was summarized by Mellett in 1968. The sediments of the Shand -Gol Svita, term and concept used by local and Soviet workers, frequently form the summit of the Paleogene section in the southern half of Mongolia. They are rather uniform, very widely distributed and consist principally of red clays, pelites and sands or, more rarely, of sandstone and gravels. Their thickness also shows little variation and is relatively slight: 30-40 m is common and it rarely attains 100 m (in contrast to the 2,600 feet cited by Mellett for the formation). This lithostratigraphic homogeneity, coupled with a good paleontologic characterization, renders the beds particularly useful. A progressive passage connects the Shand-Gol Svita with the underlying sediments of the early Oligocene and in all the sections studied by Devyatkin, a geologist with considerable experience in the area, it is overlain with erosional disconformity by the Miocene deposits of the Loh Svita. The stratotype area of the Shand-Gol Svita (the same as that chosen by the American Museum Expedition for the Hsanda Gol Formation) is situated 2-3 km below the locality of Loh on the right bank of the Shand-Gol sayr. More complete sections occur on both sides of Tatal-Gol sayr, 15-18 km to the west of Shand-Gol.

17 Tsagan-Nur = white lake.
18 Loh (= Loo = Lu·Usu-Khudukh) = dragon.
19 Tatal-Gol (= Grand Canyon_ or Grand Gorge of American authors) = attractive stream.
20 Shand-Gol (= Hsanda Gol), shand = spring or small stream; gol implies a more or less permanent stream (sayr is more usually a dry stream bed).

Note that the name Hsanda Gol is an American transliteration for the area and formation that, according to the system cited in the introduction, is transliterated here as Shand-Gol. When referring to the formation we use the American Hsanda Gol; for the locally used svita we use Shand-Gol.

Source : MNHN, Paris

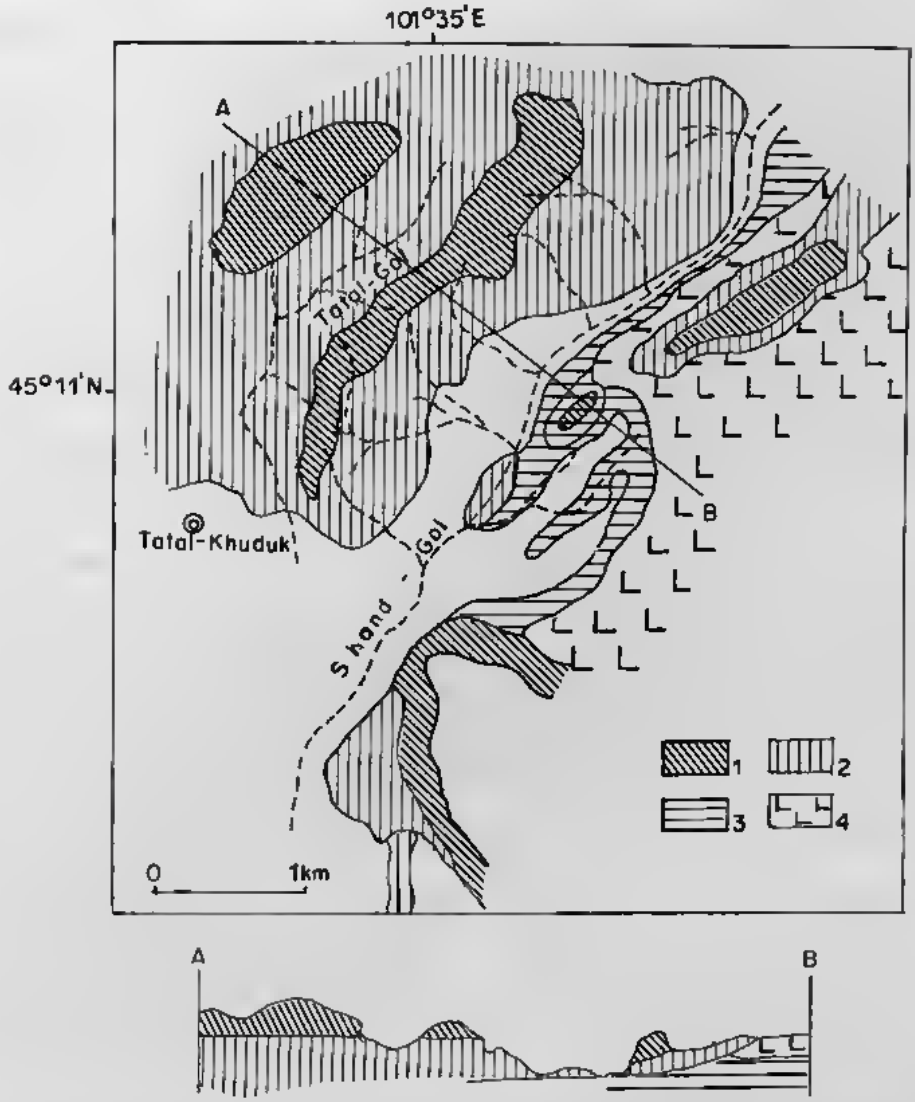


FIG. 170. — Map and cross section of the geologic structure of the southern part of the Shand-Gol locality, Mongolia. **1.** strongly carbonated red clay; **2.** red clay with less carbonate; **3.** red clay with no carbonate; **4.** basalt of the Shand-Gol Svita. Modified from Goroshko & Kurochkin, 1979.

The section at Tatal-Gol (from top to bottom), is as follows:

6. Red sandy clays with manganese stains; sandstone lenses occur in which are flat, round concretions. In the upper parts the clay becomes more pelitic ..... 10.0-12.0 m
5. A pinkish white marl deposited on the uneven surface of the underlying basalt, particularly filling the depressions..... 0.5 m
4. Dark gray basalt, the upper 20-30 cm of which are rather badly weathered. 2.0-3.0 m
3. Red unstratified clay or pelite with manganese stains ..... 4.0 m
2. Red sandy clay locally with concretions. ..... 5.0 m
1. Very coarse or gravelly white sand. 3.0-4.0 m

Total thickness of the svita is about 25 m.

The section at Shand-Gol is the following:

5. Reddish brown, unstratified clay with white marly concretions 10-20 cm in diameter..... ..... 1.0-1.5 m
4. Light red and pink limey sandstone. 0.5 m
3. Dark to light sandy clay with lenses of small gravel or of sandstone (10-20 cm). 7.0-8.0 m
2. White sands with locally brownish stains of iron origin; the lower part becomes cemented to form sandstone (0.5-1.0 m)..... 3.0-4.0 m
1. Yellowish to red unstratified clay with lenses of gypsum..... 5.0 m

Source : MNHN, Paris

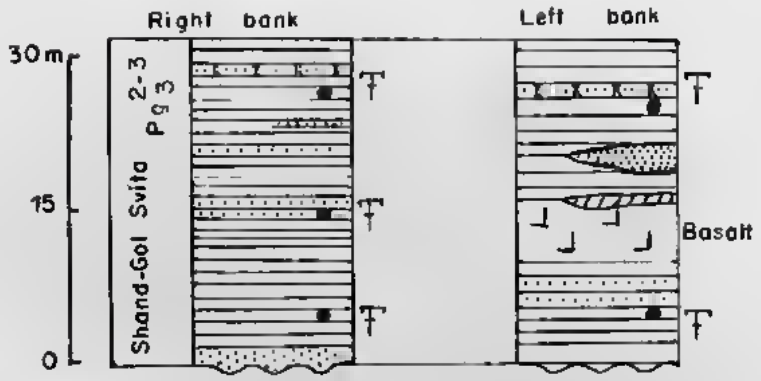


FIG. 171. — Sections on the right bank (N) and left bank (S) of the Talal Gol, Mongolia, showing the position of the fossiliferous levels and the basalt. Modified from Badamgarav *et al.*, 1975.

Considerable precision concerning the occurrence of fossil material was afforded by the results of field investigations undertaken by Goroshko and Kurochkin (1979). They found the greatest concentration of fossils in the lowest level of the supra-basalt beds; the concentration decreased upward in the section, but increased again in the highest level, a bed of concretionary marl. In contrast to previous suppositions that richness in fossil content was approximately the same below and above the basalt, Goroshko and Kurochkin, by careful collecting and quarrying, were able to show that the infra-basalt beds were extremely poor; the impression of their being fossiliferous that was gained by previous collectors was due to erosion of the upper beds and redeposition of fossil material in the superficial layers of the lower ones. In areas where the basalt lacked, the supra- and infra-basalt beds could be distinguished by the carbonate content of the former and the absence of carbonate cement in the lower beds.

While estimates of the age of the Shand Gol fauna ranged from early Oligocene to Miocene, Mellett's analysis and comparison with both the European and North American faunas indicates that the assemblage is probably representative of the middle of the Oligocene. As he pointed out, the Shand-Gol fauna is relatively balanced and diverse. It is of considerable importance, therefore, as a well dated reference mammalian locality.

Radiometric dates of 32.0 and 31.3 MY (corrected to 32.8 and 32.1 MY) were obtained from the basalt bed at Tatal-Gol by Evernden *et al.*, 1964; Soviet work has produced a similar date (Gabunia *et al.*, 1975).

Concerning the possibility that the Shand-Gol sediments might also represent late Oligocene time (as, for example, in Devyatkin, 1981), Goroshko and Kurochkin (1979) remark that in no case can this be confirmed paleontologically. A similar sedimentary sequence in the Beger-Nur depression, which is sometimes cited as supplying evidence for a late Oligocene element in the series, has also failed to produce confirming fossil material.

According to Mellett's (1968) lists, *Amphechinus rectus, Palaeoscaptor acridens, Tupaiodon morrisi, Tupaiodon? minutus, Tachyoryctoides obrutschewi, Tachyorctoides pachygnathus, Tataromys sigmodon, Amphicticeps shackelfordi, Cynodictis? constans, Amphicynodon teilhardi* and *Palaeoprionodon gracilis*, were not found in the Tatal-Gol locality but are from other sites in the area. It is not known to the authors if they have been collected at Tatal-Gol by the various expeditions that have worked there in the years subsequent to 1925[21].

21 The name Tatalyn-Khuduk has sometimes been used (for example, Dashzeveg, 1963, V.P. (3)) to designate a collecting area near Tatal-Khuduk (= Tatal well), situated near the mouth of Talal-Gol.

Source : MNHN, Paris

Fauna of the Shand-Gol Svita at Tatal-Gol

INSECTIVORA

ERINACEIDAE
- *Amphechinus rectus* (Matthew & Granger, 1924b) Butler, 1984
  (= *Amphechinus? rectus* (Matthew & Granger, 1924b) Butler, 1948)
  (= *Palaeoscaptor rectus* Matthew & Granger, 1924b)
- *Palaeoscaptor acridens* Matthew & Granger, 1924b
  (= *Amphechinus acridens* (Matthew & Granger, 1924b) Butler, 1948)
- *Exallerix hsandagolensis* McKenna & Holton, 1967
- *Tupaiodan morrisi*[22] Matthew & Granger, 1924b
- *Tupaiodon? minutus* Matthew & Granger, 1924b
- (= *Ictopidium tatalgolensis* Sulimski, 1969/1970; opinion of the authors)

SORICIDAE
- *Gobisorex kingae* Sulimski, 1969/1970

LAGOMORPHA

LEPORIDAE
- *Ordolagus teilhardi* (Burke, 1941) de Muizon, 1977
  (= *Gobiolagus? teilhardi* Burke, 1941)

OCHOTONIDAE
- *Desmatolagus gobiensis* Matthew & Granger, 1923d
  (= *Procaprolagus orlovi* Gureyev, 1960, *in* Sych, 1975)
  (= *Procaprolagus mongolicus* Gureyev, 1960, *in* Sych, 1975)
- *Procaprolagus vetustus*, (Burke, 1941) Gureyev, 1960
  (= *Desmatolagus vetustus* Burke, 1941)
  (= *Desmatolagus gobiensis* Matthew & Granger, 1923d, *in* Sych, 1975; de Muizon (1977) follows Gureyev, 1960)
- *Procaprolagus maximus* Gureyev, 1960
  (= *Desmatolagus robustus* Matthew & Granger, 1923d, *in* Sych, 1975; de Muizon (1977) follows Gureyev, 1960)
- *Sinolagomys tatalgolicus* Gureyev, 1960
  (= *Desmatolagus gobiensis* Matthew & Granger, 1923d, *in* Sych, 1975; de Muizon (1977) follows Gureyev, 1960)
- "*Desmatolagus*" *robustus* (Matthew & Granger, 1923 d) de Muizon, 1977
  (= *Desmatolagus robustus* Matthew & Granger, 1923d)
  (= *Agispelagus youngi* Gureyev, 1960, *in* Sych, 1975)
- *Agispelagus simplex* Argyropulo, 1940
- *Ochotonolagus argyropuloi* Gureyev, 1960

RODENTIA

TSAGANOMYIDAE[23]
- *Tsaganomys altaicus* Matthew & Granger, 1923c
  (= *Beatomys bisus* Shevyreva, 1972, *in* Kowalski, 1974; still considered valid by Shevyreva, 1976)
- *Cyclomylus lohensis* Matthew & Granger, 1923c
  (= *Pseudotsaganomus mongolicus*[24] Vinogradov & Gambaryan, 1952, *in* Mellett, 1968)
  (= *Sepulkomus eboretus* Shevyreva, 1972; *in* Kowalski, 1974; still considered valid by Shevyreva, 1976)

CYLINDRODONTIDAE
- *Pseudocylindrodon mongolicus* Kowalski, 1974
  (= *Pseudocylindrodon* sp.; cited by Vinogradov & Gambaryan, 1952)
  (= cf. *Pseudocylindrodon* sp.; cited by Mellet, 1968)

22 Referred to the Erinaceidae by Butler, 1981.
23 *Fide* Patterson & Wood, 1982.
24 Considered valid by Wood, 1974, and invalid by Kowalski, 1974, and Shevyreva, 1976.

Source : MNHN, Paris

APLODONTIDAE	— *Prosciurus lohiculus*[25] Matthew & Granger, 1923d
	— *Prosciurus arboraptus* Shevyreva, 1976. (= *Prosciurus arboraptus* Shevyreva, 1971, *nomen nudum*)
APLODONTIDAE?	— *Selenomys mimicus* Matthew & Granger, 1923d
CRICETIDAE	— *Cricetops dormitor* Matthew & Granger, 1923d (= *Cricetops elephantus* Shevyreva, 1965, *in* Kowalski, 1974)
	— *Cricetops* cf. *aeneus* Shevyreva, 1965; cited by Kowalski, 1974
	— *Eucricetodon asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977; see also Lindsay, 1978 (= *Eumys asiaticus* Matthew & Granger, 1923d)
TACHYORYCTOIDIDAE[26]	— *Tachyoryctoides obrutschewi* Bohlin, 1937; cited by Mellet, 1978
	— *Tachyoryctoides pachygnathus* Bohlin, 1937; cited by Mellett, 1968
	— *Tachyoryctoides tatalgolicus* Dashzeveg, 1971
CTENODACTYLIDAE	— *Tataromys sigmodon* Matthew & Granger, 1923d
	— *Tataromys plicidens* Matthew & Granger, 1923d
	— *Tataromys deflexus* Teilhard de Chardin, 1926; cited by Mellett, 1968
	— *Karakoromys decessus* Matthew & Granger, 1923d
	— *Leptotataromys*? sp.; cited by Mellett, 1968
	— *Woodomys chelkaris* Shevyreva, 1971 (= *Woodromys chelkaris* Shevyreva, 1968, *nomen nudum*)
DIPODIDAE	— *Parasminthus tangingoli* Bohlin, 1946 (= *Plesiosminthus tangingoli* Bohlin, 1946); cited by Kowalski, 1974)
CARNIVORA	
MIACIDAE	— *Amphicticeps shackelfordi* Matthew & Granger, 1924a
CANIDAE	— *Cynodictis? elegans* Matthew & Granger, 1924a
	— *Cynodictis? constans* (Matthew & Granger, 1924a) Mellett, 1968 (= *Viverravus constans* Matthew & Granger, 1924a)
	— *Amphicynodon teilhardi* (Matthew & Granger, 1924a) Mellett, 1968 (= *Cynodon teilhardi* Matthew & Granger, 1924a) (= *Cynodictis mongoliensis* Yanovskaya, 1970); Lange-Badré, pers. com., 1984)
FELIDAE	— cf. *Nimravus* sp.; cited by Mellett, 1968
	— cf. *Proailurus* sp.; cited by Mellett, 1968
MUSTELIDAE	— *Palaeogale ulysses* (Matthew & Granger, 1924a) Simpson, 1946 (= *Bunaelurus ulysses* Matthew & Granger, 1924a) (= *Bunaelurus parvulus* Matthew & Granger, 1924a, *in* Simpson, 1946) (= *Palaeogale parvula* (Matthew & Granger, 1942a), *in* de Bonis, 1981; considered a valid species by Mellett, 1968)
	— cf. *Plesictis* sp.; cited by Mellett, 1968
VIVERRIDAE	— *Palaeoprionodon gracilis* Matthew & Granger, 1924a
CREODONTA	
HYAENODONTIDAE	— *Hyaenodon pervagus* Matthew & Granger, 1924a
	— *Hyaenodon dubius* Filhol, 1873 (= *Hyaenodon aymardi* Filhol, 1882, *in* Lange-Badré, 1979; cited by Gromova, 1952)

25 Referred to *Plesiospermophilus* by Wood (1962) and Shevyreva (1976); retained in *Prosciurus* by Kowalski (1974) and by Schmidt-Kittler and Vianey-Liaud (1979); the latter considered the species to be aplodontid.

26 The Tachyoryctoidinae was created by Schaub in 1958 and raised to family status by Fejfar, 1972, not de Bruijn *et al.*, 1981, although the latter enlarged the concept.

Source : MNHN, Paris

— *Hyaenodon filholi* Schlosser, 1887; cited by Lange-Badré, 1979
(= *Hyaenodon compressus* Filhol, 1876, *in* Lange-Badré, 1979; cited by Gromova, 1952)
— *Hyaenodon* n. sp.; cited by Lange-Badré, 1979
(= *Hyaenodon ambiguus* Martin, 1906; cited by Gromova, 1952)
(note: *H. ambiguus* Martin, 1906, is synonymized with *H. gervaisi* Martin 1906, by Lange-Badré, 1979)

PERISSODACTYLA

HYRACODONTIDAE — *Indricotherium transouralicum* Pavlova, 1922, *in* Gromova, 1959
(= *Baluchitherium grangeri* Osborn, 1923a; see also Granger & Gregory, 1936)

RHINOCEROTIDAE — *Eggysodon minor* (Belyayeva, 1954c) Brunet, 1979
(= *Allacerops turgaica minor* Belyayeva, 1954c)

ARTIODACTYLA

LEPTOMERYCIDAE — cf. *Mioneryx* sp.; cited by Mellett, 1968

CERVIDAE — *Eumeryx culminis* Matthew & Granger, 1924b

GELOCIDAE — *Pseudomeryx gobiensis* Trofimov, 1957
— *Pseudomeryx hypertalonidus* Trofimov, 1957

RUMINANTIA Indet.

— *Palaeohypsodontus asiaticus*[27] Trofimov, 1958

ORDER Indet.

DIDYMOCONIDAE — *Didymoconus colgatei* Matthew & Granger, 1924a
(= *Tshelkaria robusta* Gromova, 1960a; *in* Mellett 1968)
— *Didymoconus berkeyi* Matthew & Granger, 1924a

Lat. 45° 22′ N, approx.
Long. 101° 35′ E, approx.

Fig. 1, n° 22

MONGOLIA

OBOR-KHANGAY PROVINCE

Shand-Gol Svita — **middle Oligocene**

Locality: Buil'stiyn-Khuduk

The locality of Buil'stiyn Khuduk[28] is situated on the northern slope of the Valley of Lakes, about 25 km N of the eastern border of Lake Tsagan-Nur[29]. It represents a western continuation of the Shand-Gol Svita. The main exposure extends N-S for approximately 1.5 km, cropping

27 In order to positively identify bovids, horn cores are necessary. Dentitions can be inadequate if the form is taxonomically uncertain, and the teeth of *Palaeohypsodontus* possess characters not typical of early bovids. For example, the sides of the teeth are parallel with a surprising hypsodonty and the trigonid of M/1 lacks a fossette. These are characters that are much too advanced for a middle Oligocene bovid, one that is supposedly the first representative of the family at that. H. Thomas (pers. com., 1983) recommends that this taxon be classified with a precision not exceeding that of Ruminantia indeterminate.

28 Buil'stiyn-Khuduk (= Buylstyeen-Khuduk) = almond tree well. According to Dashzeveg (pers. com., 1985), the locality referred to as Buylyasutuin-Khuduk is the same as Buil'stiyn-Khuduk.

29 Tsagan-Nur (= Tsagan-Nor) = white lake. This lake (sometimes called Takhin (small) Tsagan-Nur) is situated southwest of Shand-Gol in the eastern part of the Valley of Lakes.

Source : MNHN, Paris

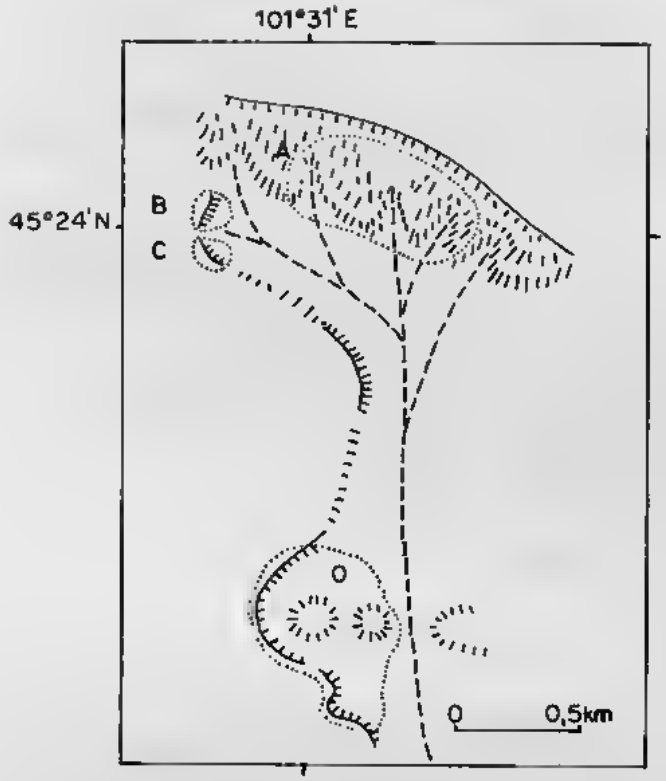


FIG. 172. — Sketch map of the locality of Buil'stiyn-Khuduk, Mongolia. A-D, areas encircled by dotted lines indicate where prospecting for fossils was carried out by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968-1969.

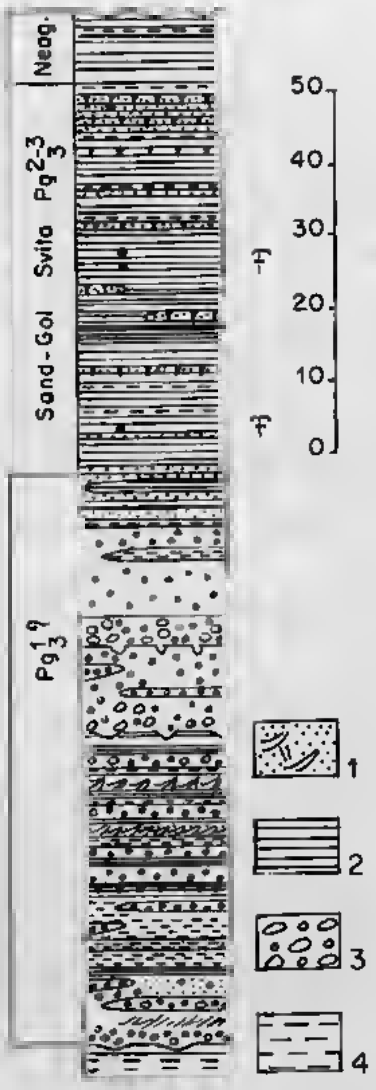


FIG. 173. — Stratigraphic section at Buil'stiyn-Khuduk, Mongolia. 1. sand with crossbedding; 2. clay; 3. conglomerate; 4. silt. Modified from Badamgarav *et al.*, 1975.

out in a cliff about 60 m high dissected by shallow gorges. The Polish-Mongolian Paelontological Expedition of 1964 explored here for about half a day; only a few unidentifiable bone fragments were found. But not far to the south is an area (D, on the map, Fig. 172) that yielded a typical Oligocene fauna, with cylindrodontid and other rodents, lagomorphs and small artiodactyls.

In the northern exposures (point A), the sediments are mostly red mudstone, but dark mudstones and siltstones also occur which are gray or gray-violet in color. Points B, C and D, along the western side of a dry stream bed, contain bright brick red mudstones with occasional interbedded light brown sands and sandstones.

Source : MNHN, Paris

Fauna of the Shand-Gol Svita at Buil'stiyn-Khuduk

LAGOMORPHA

OCHOTONIDAE
— *Desmatolagus gobiensis* Matthew & Granger, 1923d; cited by Sych 1975
— Lagomorpha indet.; cited by Badamgarav *et al.*, 1975

RODENTIA

TSAGANOMYIDAE
— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974
(= *Beatomys bisus* Shevyreva, 1972, *in* Kowalksi, 1974; still considered valid by Shevyreva, 1976; cited by Badamgarav *et al.*, 1975)
— *Cyclomylus lohensis* Matthew & Granger, 1923c
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952, *in* Mellett, 1968; cited by Kowalski, 1974)

APLODONTIDAE?
— *Selenomys mimicus* Matthew & Granger, 1923d; cited by Badamgarav *et al.*, 1975

CRICETIDAE
— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Kowalski, 1974

ARTIODACTYLA Indet.; cited by Kielan-Jaworowska & Dovchin, 1968/1969

Lat. 45° 15′ N, approx.
Long. 102° E, approx.

Fig. 1, n° 25

MONGOLIA
OBOR-KHANGAY-PROVINCE
Valley of Lakes

Shand-Gol Svita **middle Oligocene**
Locality: Ikh-Argalantu-Nuru

At the southern foot of Ikh-Arganlatu-Nuru[30] Mountain, at a site called Taban-Yagan[31], a section typical of the Shand-Gol sediments has yielded a small collection of mammals. Field work and collecting was done in the area (see map Fig. 75, p. 146) in the 1970's by Devyatkin, Badamgarav, Borisoglebskaya and Liskun.

Fauna of the Shand-Gol Svita at Ikh-Argalantu-Nuru

LAGOMORPHA Indet.; cited by Shevyreva in Badamgarav *et al.*, 1975

RODENTIA

TSAGANOMYIDAE
— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Shevyreva in Badamgarav *et al.*, 1975
— *Cyclomylus lohensis* Matthew & Granger, 1923c
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952; cited by Shevyreva in Badamgarav *et al.*, 1975)

30 Ikh-Argalantu-Nuru (= Ikh-Arganlantu-Nuru) = big ram range.
31 Taban-Yagan = five pink (probably hills).

Source : MNHN, Paris

APLODONTIDAE? — *Selenomys mimicus* Matthew & Granger, 1923; cited by Shevyreva in Badamgarav *et al.*, 1975

CRICETIDAE — *Cricetops dormitor* Matthew & Granger, 1923d; cited by Shevyreva in Badamgarav *et al.*, 1975

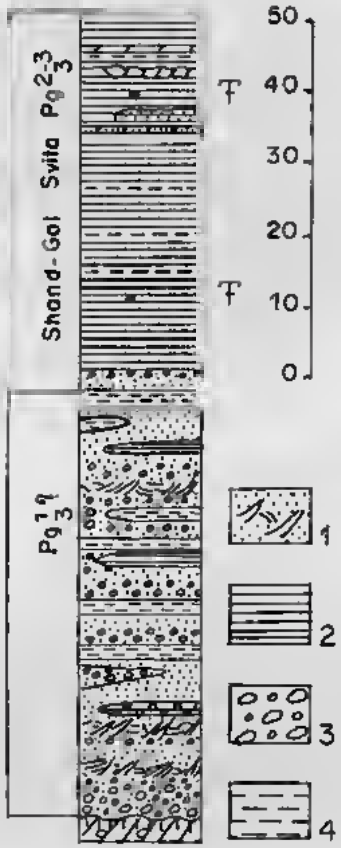


FIG. 174. — Stratigraphic section at Ikh-Argalantu-Nuru, Mongolia. 1. sand with crossbedding; 2. clay; 3. conglomerate; 4. silt. Modified from Badamgarav *et al.*, 1975.

MONGOLIA

OBOR-KHANGAY PROVINCE

VALLEY OF LAKES

Shand-Gol Svita **middle Oligocene**

Localities: Khotorin-Dondzhi, Tsagan-Obo and Khunuk

The localities of Khotorin-Dondzhi (see map Fig. 75, p. 146), Tsagan-Obo[32] and Khunuk are scattered along the middle course of the Tatsin-Gol[33]. They were found and exploited in the years around 1970 and were described in detail by Badamgarav *et al.*, 1975. Goroshko & Kurochkin (1979) added further comments and noted that a confusion exists in the text of Badamgarav *et al.*; the vertebrate fossils at Tsagan-Obo are cited as having been collected from beds above a basalt, but are indicated as infra-basaltic in the faunal list; during their field work, Goroshko & Kurochkin found fossils only in the supra-basaltic beds. Devyatkin (1981) gives a

32 Tsagan-Obo = white obo.
33 Tatsin-Gol = attractive stream.

Source : MNHN, Paris

faunal list for Tsagan-Obo 1.5, which according to Dashzeveg (pers. com., 1985) combines the lists for Tsagan-Obo 1 and 2.

At Khotorin-Dondzhi and Khunuk the vertebrate material was found in sediments filling depressions adjacent to the basalts; at Tsagan-Obo only the supra-basaltic sediments furnished fossils. Dashzeveg (pers. com., 1985) claims that the sites of Khotorin-Dondzhi and Khunuk are Neogene in age. Concerning the latter, Badamgarav *et al.* situate it 20-25 km northwest of Tsagan-Khutel. In the publication by Berkey, Granger & Morris (1929) Khunuk Valley (in their Fig. 2) is placed east of a region marked "Eocene Badlands" (this is the site of Tsagan-Khutel); but corroborating the statement by Badamgarav *et al.*, Dashzeveg (pers. com., 1985) notes that the position of Khunuk Valley by the American authors is in error; this "Khunuk" Valley is really called Mongol Valley and the true Khunuk is farther to the northwest.

Fauna of the Shand-Gol Svita at Khotorin-Dondzhi

PERISSODACTYLA

AMYNODONTIDAE Indet.; cited by Goroshko & Kurochkin, 1979

Badamgarav *et al.*, 1975, remark that Tsagan-Obo 1 is 3 km south of Tsagan-Obo brigade (= Brigada), but actually it is southwest of Brigada.

Fauna of the Shand-Gol Svita at Tsagan-Obo 1 and 2

INSECTIVORA

ERINACEIDAE — cf. *Palaeoscaptor acridens* Matthew & Granger, 1924b; cited by Devyatkin, 1981

LAGOMORPHA

OCHOTONIDAE — *Sinolagomus tatalgolicus* Gureyev, 1960; cited by Dashzeveg in Badamgarav *et al.*, 1975

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Dashzeveg in Badamgarav *et al.*, 1975
(= *Beatomys bisus* Shevyreva, 1972, *in* Kowalski, 1974; still considered valid by Shevyreva, 1976; cited by Devyatkin, 1981)
— *Cyclomylus lohensis* Matthew & Granger, 1923c
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952, *in* Mellett, 1968; cited by Dashzeveg in Badamgarav *et al.*, 1975

APLODONTIDAE? — *Selenomys mimicus* Matthew & Granger, 1923d; cited by Devyatkin, 1981

CRICETIDAE — *Cricetops dormitor* Matthew & Granger, 1923d; cited by Dashzeveg in Badamgarav *et al.*, 1975

TACHYORYCTOIDIDAE — *Tachyoryctoides tatalgolicus* Dashzeveg, 1971; cited by Dashzeveg in Badamgarav *et al.*, 1975
— *Tachyoryctoides obrutschewi* Bohlin, 1937; cited by Devyatkin, 1981

CARNIVORA

MUSTELIDAE — *Palaeogale* cf. *ulysses* (Matthew & Granger, 1924a) Simpson, 1946; cited by Dashzeveg in Badamgarav *et al.*, 1975
(= *Bunaelurus ulysses* Matthew & Granger, 1924a)

ARTIODACTYLA

CERVIDAE — *Eumeryx culminus* Matthew & Granger, 1924b; cited by Dashzeveg in Badamgarav *et al.*, 1975
— *Eumeryx* sp.; cited by Dashzeveg in Badamgarav *et al.*, 1975

TRAGULIDAE Indet.; cited by Dashzeveg in Badamgarav *et al.*, 1975

Source : MNHN, Paris

Lat. 45° 20′ N, approx.
Long. 100° 45′ E, approx.

Fig. 1, n° 19

MONGOLIA
OBOR-KHANGAY PROVINCE
VALLEY OF LAKES

Shand-Gol Svita **middle Oligocene**
Locality: Menkhen-Teg

The Eocene and early Oligocene parts of the sequence of sediments at this locality have already been discussed.

The Shand-Gol Svita crops out at Menkhen-Teg in a high escarpment (up to 30 m in height) for about 3 km. It is represented by sandy and marly clays attaining a maximum of 25 m. In the northern part of the outcrop the thickness of the svita diminishes to 2 m, due to beveling of the lower beds. This has been interpreted to mean that the area at Menkhen-Teg was already high in the Oligocene.

The fossiliferous levels occur in sediments that have filled in former depressions in the paleorelief. The fauna collected is typical of that at Shand-Gol.

Fauna of the Shand-Gol Svita at Menkhen-Teg

LAGOMORPHA

OCHOTONIDAE
— *Sinolagomys* cf. *tatalgolicus* Gureyev, 1960; cited by Dashzeveg in Badamgarav *et al.*, 1975

RODENTIA

TSAGANOMYIDAE
— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Dashzeveg in Devyatkin, 1981
— *Cyclomylus lohensis* Matthew & Granger, 1923c; cited by Dashzeveg in Badamgarav *et al.*, 1975
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952, *in* Mellett, 1968; cited by Dashzeveg in Badamgarav *et al.*, 1975)

APLODONTIDAE?
— *Selenomys mimicus* Matthew & Granger, 1923d; cited by Dashzeveg in Devyatkin, 1981

CRICETIDAE
— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Dashzeveg in Badamgarav *et al.*, 1975

ARTIODACTYLA

CERVIDAE
— *Eumeryx culminis* Matthew & Granger, 1924b; cited by Dashzeveg in Devyatkin, 1981

Source : MNHN, Paris

Lat. 43° 27′ N, approx.
Long. 100° 23′ E, approx.

Fig. 1, n° 12

MONGOLIA
OMONO GOBI PROVINCE
Nemegt Depression

Shand-Gol Svita **middle Oligocene**
Locality: Ulan-Khureh

This locality, the only one of Oligocene age in the Nemegt Depression, is situated on the southern edge of the basin several kilometers south of Tsagan Sayr. Ulan-Khureh[34] was discovered in 1970 by the Soviet-Mongolian Paleontological Expedition and was exploited in 1978 and 1980 by succeeding expeditions. Reshetov (pers. com., 1984) considers the fossil producing sediments to represent the Shand-Gol Svita; in any case, they possess an aspect typical of the Shand-Gol red beds and the recovered fauna is compatible with such a designation. A complete section is not visible in any one place in this area, but the Oligocene beds are overlain by the Neogene to Quaternary Gobi Conglomerate and unconformably underlain by the Naran-Bulak Svita. Their thickness is 15-20 m.

Fauna of the Shand-Gol Svita at Ulan-Khureh

LAGOMORPHA Indet.; cited by Badamgarav & Reshetov, 1985

RODENTIA

CYLINDRODONTIDAE Indet.; cited by Badamgarav & Reshetov, 1985

CRICETIDAE — *Cricetops* cf. *dormitor* Matthew & Granger, 1923d; cited by Badamgarav & Reshetov, 1985

ARTIODACTYLA Indet.; cited by Badamgarav & Reshetov, 1985

Lat. 45° 55′ N
Long. 97° E

Fig. 1, n° 2

MONGOLIA
GOBI ALTAY PROVINCE
Beger-Nur Basin

Beger Svita **middle Oligocene**
Locality: Beger-Nur

The Beger-Nur Basin forms the western extremity of the Valley of Lakes. The basin is bounded to the north by the granitic mass of Serkh-Ula[35] and Tayshiren-Ula[36], and to the south by the Mongol Altay ridge. A salt lake, Beger-Nur, occupies the central part of the basin, surrounded by intermittent salt marshes.

The Tertiary series in the Berger-Nur Basin of

34 Ulan-Khureh = red monastery.
35 Serkh-Ula = ram mountain.
36 Tayshiren-Ula (= Tayshirin-Ula) = great (in the sense of grandiose) mountain.

Source : MNHN, Paris

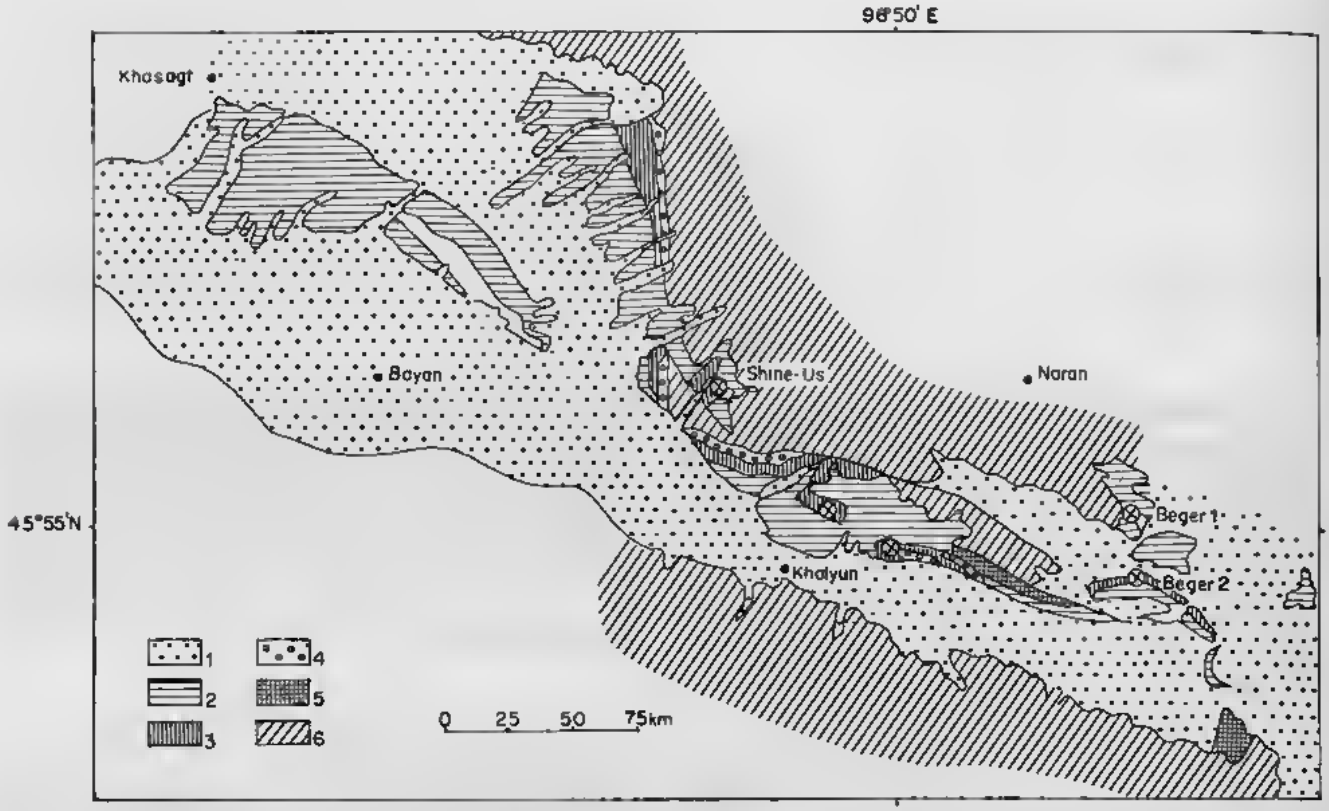


FIG. 175. — Map of the Cenozoic beds of Khalyun Somon (county), Mongolia. Beger 1 is a Miocene site. Beger 2 is the middle Oligocene locality worked by the Polish-Mongolian Expedition and by Devyatkin; the Khalyun localities are situated to the east and to the north of Khalyun village; Shine-Us is a minor middle Oligocene site. 1. alluvium or lacustrine deposits; 2. Neogene; 3. Beger Svita; 4. Khan-Tayshiri Svita; 5. Mesozoic. 6. Paleozoic. Modified from Devyatkin, 1981.

western Mongolia were first examined by Razumovskaya (1946) who collected mostly in the Neogene deposits. Further work in the basin was done by the Soviet Paleontological Expedition of 1949 (Rozhdestvenskiy, 1954) and the Geological Expedition of 1965 (Devyatkin and Liskun, 1966). The Beger-Nur region was also visited by the Polish-Mongolian Paleontological Expedition of 1965; 8 days of collecting revealed that the Oligocene beds were poorly fossiliferous. The richest area was in the southern part of the basin where a cylindrodontid skull was found. The geologist Devyatkin also collected at the locality.

The sediments producing the Oligocene mammals consist mainly of red sandy silts, sands, gravels and sandy conglomerates, which, according to Gradzinski *et al.*, 1968/1969, overlie an eroded early Cretaceous bed of sandy shales. Miocene sandy conglomerates, with concretions containing bones, overlie the Oligocene beds.

The section of the Beger Svita is as follows (from the top to bottom):

3. Reddish brown sandy clay with lenses of angular pebbly gravels. Limey clay concretions occur in the upper part ..... 30 m
2. Red sandy clay..... 15 m
1. Red or dark brownish sandy clay with lenses (up to 1.5 m thick) of sandstone and angular gravels ..... 35 m

Devyatkin (1981) recognizes an independant svita below the Beger Svita, the Khan-Tayshiri Svita. He suggests that the lower part of this svita should be correlated with the analogs of the Ergilin-Dzo Svita in the Valley of Lakes; he cites the discovery of a middle Oligocene fauna in the highest part of the Khan-Tayshiri Svita, which implies the existence of a late Oligocene component in the Shand-Gol (or Beger) Svita. This paleontological evidence has been contested by Goroshko & Khurochkin (1979).

Source : MNHN, Paris

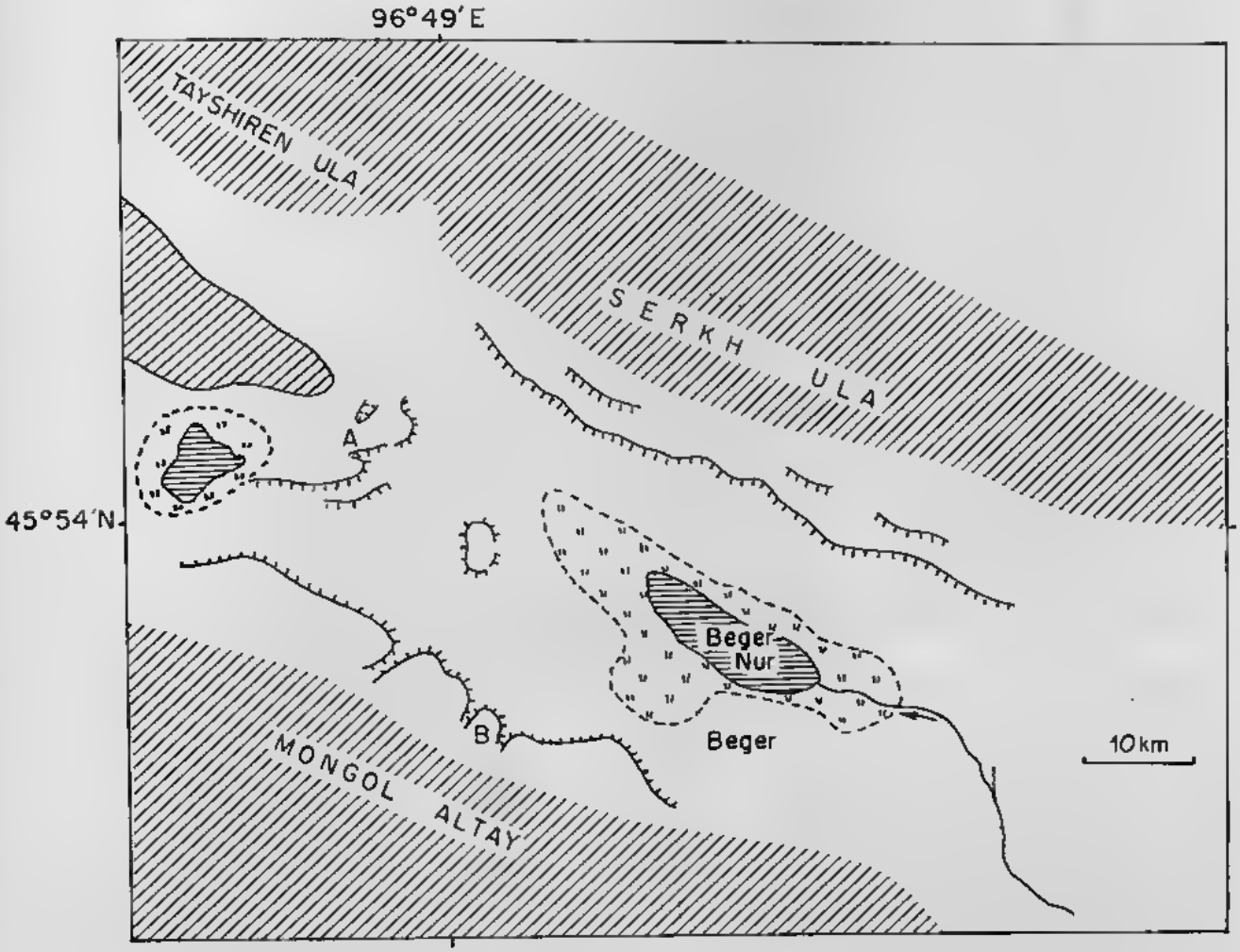


FIG. 176. — Sketch map of the Beger-Nur Basin, Mongolia. A and B are points where the Polish-Mongolian Expedition collected in 1965. Modified from Gradzinski *et al.*, 1968/1969.

Fauna of the Beger Svita at Beger-Nur

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974

CRICETIDAE — *Cricetops dormitor* Matthew & Granger, 1923d; cited by Devyatkin, 1981

TACHYORYCTOIDIDAE — *Tachyoryctoides obrutschewi* Bohlin, 1937; cited by Devyatkin, 1981

CTENODACTYLIDAE — *Tataromys*? sp.; cited by Devyatkin, 1981

Source : MNHN, Paris

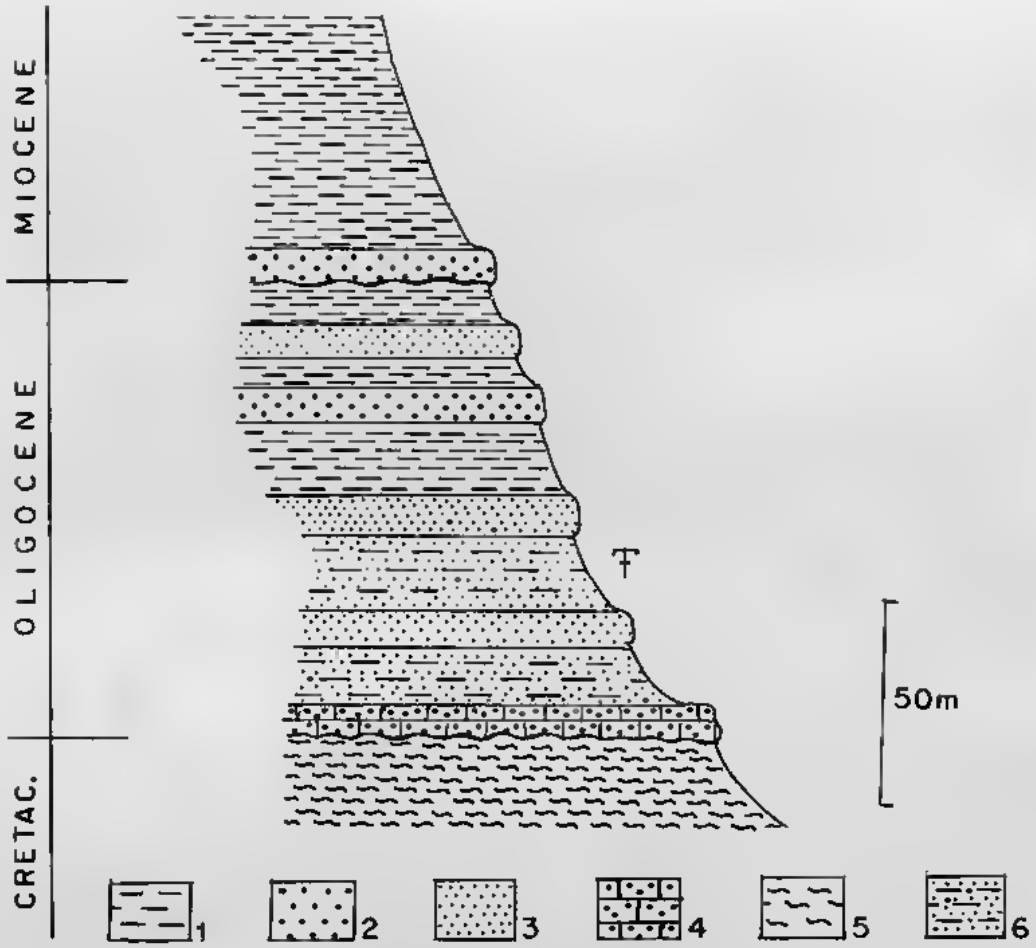


FIG. 177. — Geological section in the southern part of the Begger-Nur Basin, Mongolia. The Oligocene sediments comprise both the Begger Svita and the Khan-Tayshiri Svita. **1**. silt; **2**. gravel; **3**. sand; **4**. conglomerate; **5**. clay; **6**. sand with silt intercalations. Modified from Gradzinski *et al.*, 1968/1969.

Lat. 43° 44′ N, approx.
Long. 102° 33′ E, approx.

Fig. 1, n°15

MONGOLIA

OMONO GOBI PROVINCE

unnamed svita **middle Oligocene**

Locality: Tsakhir

Oligocene mammals were discovered in 1969 at the locality of Tsakhir[37] and exploitation continued the following year by members of the Soviet-Mongolian Paleontological Expedition. The locality is situated in the basin between the Barun-Saykhan[38] and Dzolen-Ula[39] ranges on the southern piedmont of the Tsakhir Massif in the southern part of Mongolia (see map, Fig. 23,

37 Tsakhir = white quartz.
38 Barun-Saykhan = western pretty mountain.
39 Dzolen-Ula = gentle (probably in relief) mountain.

Source : MNHN, Paris

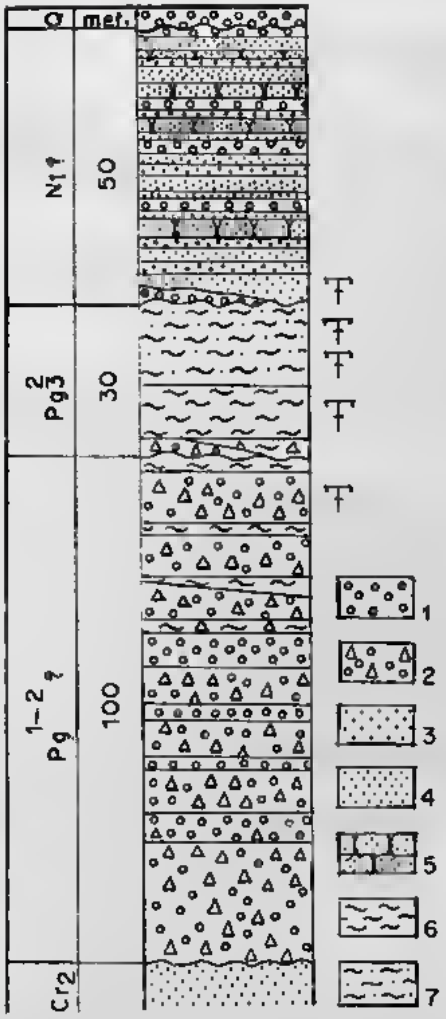


FIG. 178. — Stratigraphic section in the area of Tsakhir, Mongolia, showing the levels where fossil mammals have been found. 1. conglomerate; 2. conglomeratic breccia; 3. gravelite; 4. friable sandstone; 5. compact sandstone, with concretions; 6. clay; 7. arenaceous clay. Modified from Shuvalov & Reshetov, 1974.

p. 60). Stratigraphically, it is situated near the top of the piedmont section. Here the Cenozoic sediments can be divided into three members (none were given names in the descriptive article by Shuvalov and Reshetov, 1974): the upper, the middle and the lower.

The upper member is characterized by a level of comparatively dense yellow-gray and gray conglomerate at its base, between 0.3 and 2 m thick. Higher up is a level of weakly cemented or unconsolidated gray and yellow-gray sandstone with stringers of dense, yellow-gray limey sandstones, gravelites and conglomerates; total thickness reaches 50 m.

The middle member is subdivided into three levels, the top one consisting of 20 m of sandy, brown-buff clay; the middle one of 10 m of sandy, bright red clay; and the lower one (up to 2.5 m), which presents a rose-yellow conglomerate grading into a brick red clay containing angular gravel and rounded pebbles.

The lower member, in its bottom and middle parts, is composed mainly of conglomerate and conglomerate-breccias. The clastic material is angular and poorly sorted and is derived from Permian and late Cretaceous deposits; it is cemented by sandy calcareous material. In the top part of the member, along with the coarse clasts, are lens-like stringers of mixed grain sandstone. The thickness of the member is 100-200 m.

Each member is separated above and below by an erosional surface; late Cretaceous rocks underlie the sequence, which is capped by a thin bed (up to 4 m) of comparatively dense "Upper Gobi" conglomerate of Quaternary age.

Vertebrate fossils, all in disarticulated condition, were found mostly in the upper part of the argillaceous middle member. Other material, of very poor preservation, can be encountered in the lower levels of the upper sandstone member and in the upper level of the conglomerate-breccia member. Only the mammalian remains from the middle member provide an indication of the age of the beds, as they resemble those from other middle Oligocene assemblages. The age of the upper (Neogene?, perhaps Miocene) and the lower (early to middle Oligocene) members cannot be determined with certainty and estimates are based on lithologic similarity to the Oshin Svita and the Loh Svita (Miocene), and to the Orok-Nur[40] and Khan-Tayshir[41] Svita (early to middle Oligocene) respectively.

40 Orok-Nur = gray lake.
41 Khan-Tayshir = grand and imperial (summit?).

Source : MNHN, Paris

Fauna of the unnamed svita at Tsakhir

INSECTIVORA

ERINACEIDAE
— *Amphechinus rectus* (Matthew & Granger, 1924b) Butler, 1984
(= *Amphechinus? rectus* (Matthew & Granger 1925b) Butler, 1948
(= *Palaeoscaptor rectus* Matthew & Granger, 1924b)
(= *Palaeoscaptor* cf. *rectus* (Matthew & Granger, 1924b); cited Shuvalov & Reshetov, 1964)

LAGOMORPHA

OCHOTONIDAE
— *Desmatolagus gobiensis* Matthew & Granger, 1923d; cited by Shuvalov & Reshetov, 1974

RODENTIA

TSAGANOMYIDAE
— *Tsaganomys altaicus* Matthew et Granger, 1923c; cited by Shuvalov & Reshetov, 1974
— *Cyclomylus lohensis* Matthew & Granger, 1923c
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952, *in* Mellett, 1968; cited by Shuvalov & Reshetov, 1974)
— *Cyclomylus* sp.
(= *Pseudotsaganomys* sp., *in* Mellett, 1968; cited by Shuvalov & Reshetov, 1974)

APLODONTIDAE?
— *Selenomys mimicus* Matthew & Granger, 1923d; cited by Shuvalov & Reshetov, 1974

CRICETIDAE
— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Shuvalov & Reshetov, 1974

CTENODACTYLIDAE
— *Woodomys chelkaris* Shevyreva, 1971b; cited by Shuvalov & Reshetov, 1974

ARTIODACTYLA

ENTELODONTIDAE
— *Entelodon* sp.; cited by Shuvalov & Reshetov, 1974

LEPTOMERYCIDAE
— *Miomeryx* sp.; cited by Shuvalov & Reshetov, 1974

GELOCIDAE
— *Pseudomeryx gobiensis* Trofimov, 1957; cited by Devyatkin, 1981

Lat. 44° 5′ N, approx.
Long. 107° 10′ E, approx.

Fig. 1, n° 27

MONGOLIA

OMONO GOBI PROVINCE

Shand-Gol Svita **middle Oligocene**

Locality: Shunkht

Mammalian fossils were discovered at Shunkht[42] in the late 1960's by Dashzeveg, who published on the material in 1970. The locality is situated 15 km east of the county seat of Manlay.

The section consists mainly of 20 monotonous meters of red sandy clay. It was the upper part of the section that yielded the mammalian fossils. The fauna correlates well with that known elsewhere in the Shand-Gol Svita and its age can be considered as middle Oligocene.

42 Shunkht = vermilion colored?

Source : MNHN, Paris

Fauna of the Shand-Gol Svita at Shunkht

INSECTIVORA

ERINACEIDAE

— *Amphechinus rectus* (Matthew & Granger, 1924b) Butler, 1984
(= *Amphechinus? rectus* (Matthew & Granger, 1924b) Butler, 1948)
(= *Palaeoscaptor rectus* Matthew & Granger, 1924b; cited by Dashzeveg, 1970a)

— *Palaeoscaptor acridens* Mattbew & Granger, 1924b; cited by Dashzeveg, 1970a

LAGOMORPHA

OCHOTONIDAE

— *Ochotonolagus argyropuloi* Gureyev, 1960; cited by Dashzeveg, 1970a

RODENTIA

TSAGANOMYIDAE

— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Dashzeveg, 1970a

— *Cyclomylus lohensis* Matthew & Granger, 1923c; cited by Dashzeveg, 1970a
(= *Pseudotsaganomys mongolicus* Vinogradov & Gambaryan, 1952; cited by Dashzeveg, 1970a)

APLODONTIDAE?

— *Selenomys mimicus* Matthew & Granger, 1923d; cited by Dashzeveg, 1970a

CRICETIDAE

— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Dashzeveg, 1970a
(= *Cricetops elephantus* Shevyreva, 1965; cited by Dashzeveg, 1970a)

CTENODACTYLIDAE

— *Karakoromys* sp.; cited by Dashzeveg in Devyatkin, 1981
(= ? *Karakoromys decessus* Matthew & Granger, 1923d; cited by Dashzeveg, 1970a)

CARNIVORA

MUSTELIDAE

— *Palaeogale ulysses* (Matthew & Granger, 1924a), Simpson, 1946
(= *Bunaelurus ulysses*. Matthew & Granger, 1924a)
(= *Bunaelucus parvulus* Matthew & Granger 1924a, *in* Simpson, 1946)
(= *Palaeogale parvula* (Matthew & Granger, 1924a), *in* de Bonis, 1981; considered a valid genus by Mellett, 1968; cited by Dashzeveg, 1970a)

CREODONTA

HYAENODONTIDAE

— *Hyaenodon chunkhtensis* Dashzeveg, 1985

— *Hyaenodon* sp.; cited by Dashzeveg, 1985

PERISSODACTYLA

HYRACODONTIDAE

— *Indricotherium* sp.; cited by Dashzeveg in Devyatkin, 1981
(=? *Indricotherium transouralicum* Pavlova, 1922; cited by Dashzeveg, 1970a)

ORDER Indet.

DIDYMOCONIDAE

— *Didymoconus colgatei* Matthew & Granger, 1924a; cited by Dashzeveg, 1970a

Source : MNHN, Paris

Lat. 44° 56′ N
Long. 95° 24′ E

Fig. 1, n° 4

MONGOLIA

Gobi Altay Province

Alag-Nur Basin

unnamed svita **middle Oligocene**

Locality: Bungin-Gol

A few hours of collecting were spent at Bungin-Gol[53] by the 1964 Polish-Mongolian Paleontological Expedition. The exposures are about 4 km WNW from Buin[44] Brigade (formerly Altay village) and occur in the bottom and on the slopes of a large erosional depression situated on the northern piedmont of the Azhi-Bogdo Mountains. Small mammals were found in red mudstones, gravel and sandstones; the overlying brown clay contained rare large mammals. In Kowalski's (1974) analysis of the rodent element of the fauna, an upper and a lower level were differentiated.

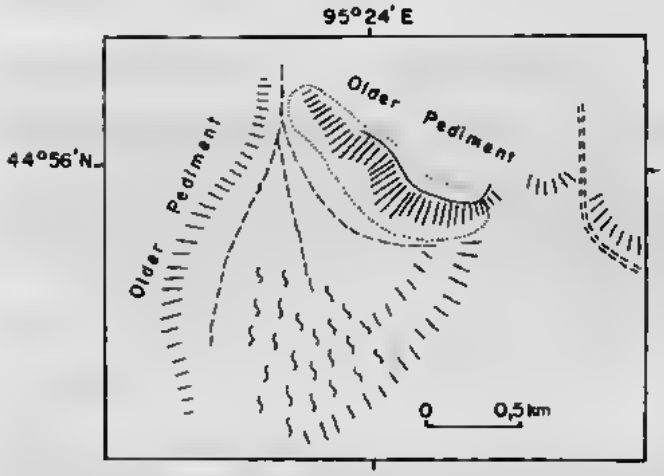


Fig. 179. — Sketch map of the Bungin-Gol locality, Mongolia. The area encircled by a dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968/1969.

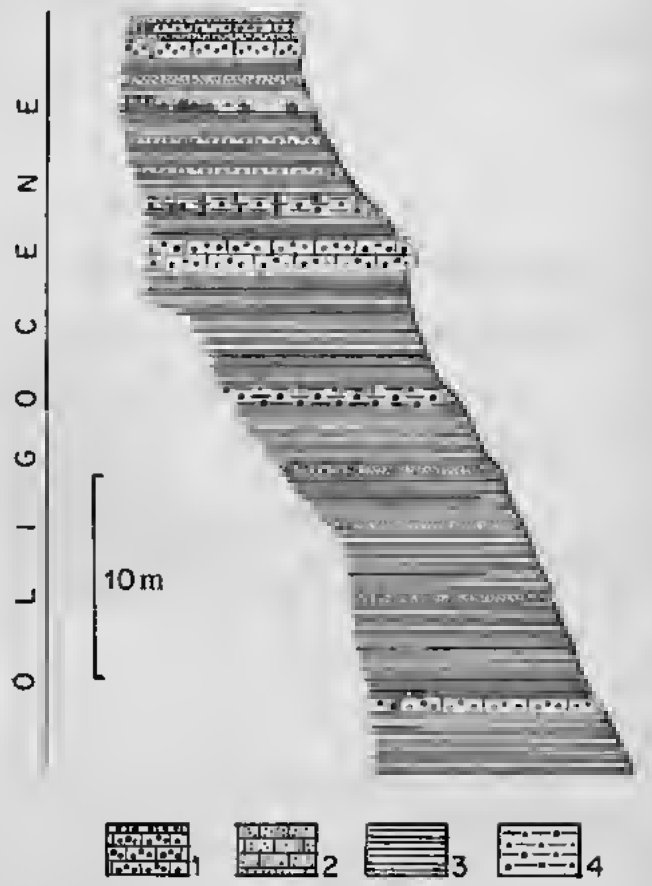


Fig. 180. — Geological profile of the Oligocene beds at the Bungin-Gol locality, Mongolia. Most of the section is composed of mudstone (3); a level of conglomerate (1) near the bottom is followed by 3 thin sandstone (2) layers, which in turn are followed by a bed of gravelly mudstone (4). Toward the top of the section conglomerates and gravels become more frequent. Modified from Gradzinski *et al.*, 1968/1969.

43 Bungin-Gol (= Boongeen Gol); Devyatkin (1981) apparently refers to this locality as northern Alak-Nur.
44 Buin (= Buyn) = shaman.

Source : MNHN, Paris

Fauna of the unnamed svita at Bungin-Gol

LAGOMORPHA

OCHOTONIDAE — *Desmatolagus gobiensis* Matthew & Granger, 1923d; cited by Sych, 1975

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974

— *Cyclomylus lohensis* Matthew & Granger, 1923c; cited by Kowalski, 1974

APLODONTIDAE — *Prosciurus lohiculus* Matthew & Granger, 1923d; cited by Kowalski, 1974

CTENODACTYLIDAE — *Karakoromys decessus* Matthew & Granger, 1923d; cited by Kowalski, 1974

ARTIODACTYLA Indet., seen in the collections at Warsaw by the authors.

Dashzeveg (1970) cites the presence of mammalian fossils at Bunchiyn-Gol Cliff in the northwest part of the Adzhi-Bogdo Mountains. Carnivores, cervids and perissodactyls were recovered and indicated a mid-Oligocene age; the material was not yet studied in 1970.

Lat. 45° 56′ N, approx.
Long. 96° 20′ E, approx.

Fig. 1, n° 3

MONGOLIA

GOVI ALTAY PROVINCE

Sharga Basin

Beger Svita **middle Oligocene**

Locality: Khalyun

Khalyun[45] is a locality of small importance, discovered by the Polish-Mongolian Expedition of 1964 on the northern side of the Gobi Altay Mountains in the Khalyun Basin. The outcrop is extensive, stretching over 30 km from east to west, and is situated at the foot of the Tayshirin-Ula Range, north of the village of Khalyun.

The Oligocene sediments consist of alternating silt, mud and mudstone of red to white color; gravels and conglomerates are sometimes present.

Fauna of the Beger Svita at Khalyun

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski 1974

45 Khalyun = light brown; literally, the color of an otter.

Source : MNHN, Paris

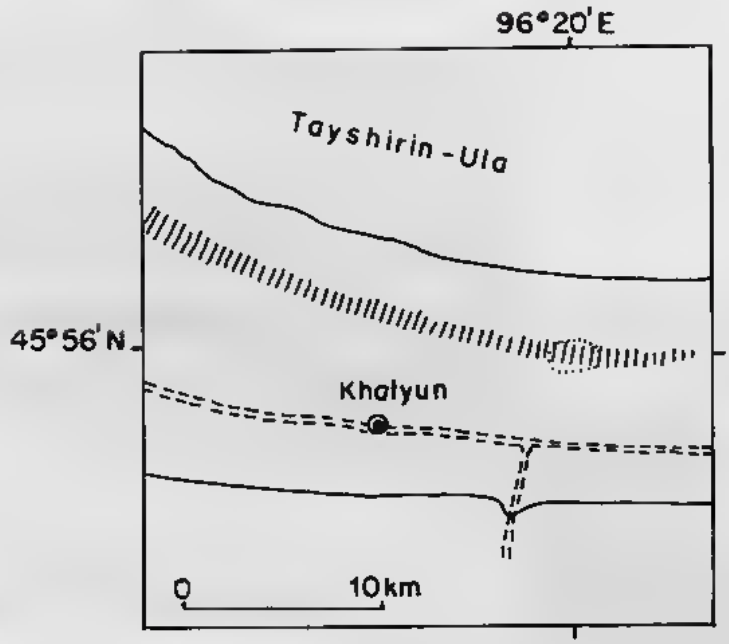


FIG. 181. — Sketch map of the Khalyun Basin, Mongolia. The area encircled by a dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968/1969.

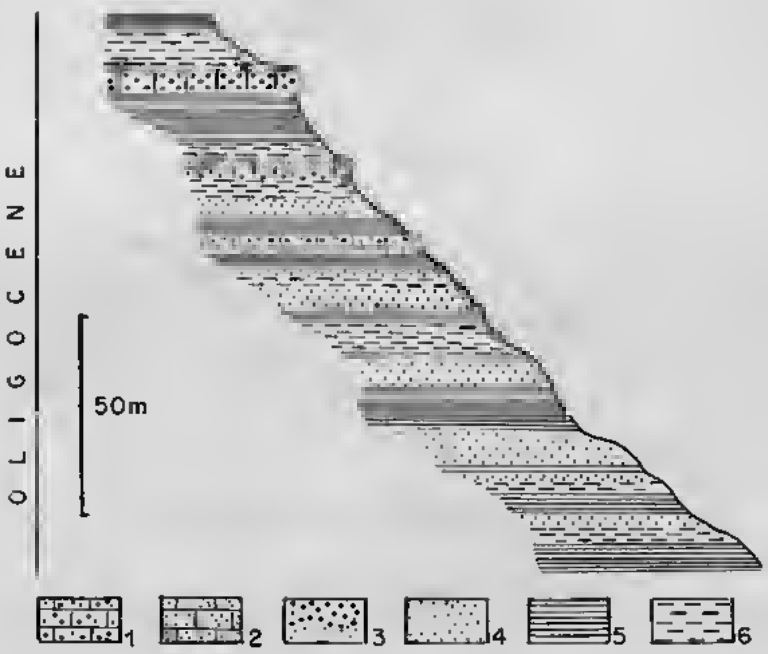


FIG. 182. — Geological profile of the Oligocene sediments at the Khalyun locality, Mongolia. **1.** conglomerate; **2.** sandstone; **3.** gravel; **4.** sand; **5.** mudstone or siltstone; **6.** silt. Modified from Gradzinski *et al.*, 1968/1969.

Source : MNHN, Paris

Lat. 44° 54′ N
Long. 96° 20′ E

Fig. 1, n° 8

MONGOLIA
GOBI ALTAY PROVINCE
Zakhoi Basin

unnamed svita **middle Oligocene**

Locality: Khatan-Khayrkhan

This is another of the localities found by the 1964 Polish-Mongolian Paleontological Expedition. It is located a few kilometers east of the Khatan-Khayrkhan[46] Range, in the western part of the Zakhoi Basin in which the settlement of Dzahooy lies. The exposures are extensive and the sediments consist of calcareous mudstones of red or orange-red color.

A rich fauna of insectivores, lagomorphs and rodents was discovered on the surface of the outcrops, the richest that was seen during the trip into western Mongolia. Only a few hours could be spent collecting there. A crew led by Devyatkin also collected in the area in the early 1970's.

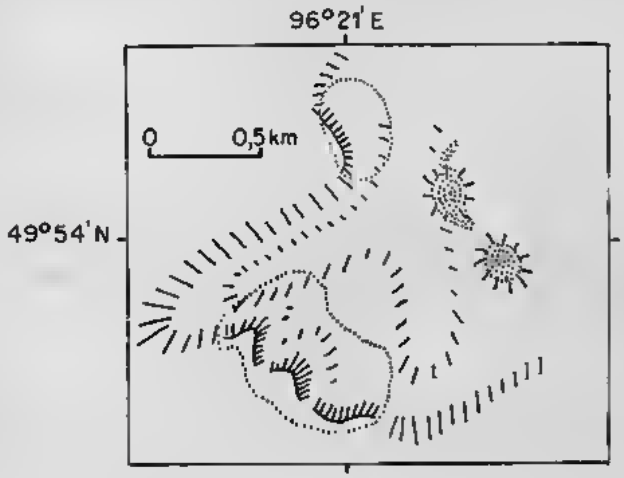


FIG. 183. — Sketch map of the locality of Khatan-Khayr-khan, Mongolia. The area encircled by dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968/1969.

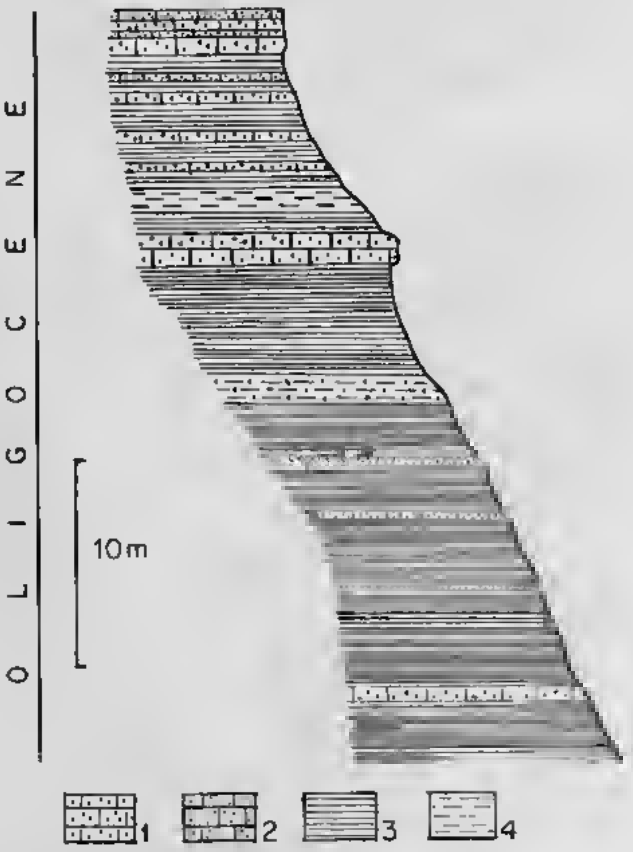


FIG. 184. — Geological profile of the Oligocene sediments at Khatan-Khayrkhan locality, Mongolia. 1 conglomerate; 2. sandstone; 3. mudstone or siltstone; 4. mudstone or mud with gravels. Modified from Gradzinski *et al.*, 1968/1969.

46 Khatan-Khayrkhan = beloved princess.

Source : MNHN, Paris

Fauna of the unnamed svita at Khatan-Khayrkhan

INSECTIVORA

ERINACEIDAE
— *Tupaiodon? minutus* Matthew & Granger, 1924b; opinion of the authors
(= *Ictopidium tatalgolensis* Sulimski, 1969/1970)

RODENTIA

TSAGANOMYIDAE
— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974
— *Cyclomylus minutus* Kowalski, 1974

APLODONTIDAE
— *Prosciurus lohiculus* Matthew & Granger, 1923d; cited by Kowalski, 1974

APLODONTIDAE?
— *Selenomys mimicus* Matthew & Granger, 1923d; cited by Devyatkin, 1981

CRICETIDAE
— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Kowalski, 1974
— *Eucricetodon asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977 (= *Eumys asiaticus* Matthew & Granger, 1923d); cited by Kowalski, 1974

CTENODACTYLIDAE
— *Tataromys gobiensis* Kowalski, 1974
— *Tataromys plicidens* Matthew & Granger, 1923d; cited by Kowalski, 1974

CARNIVORA

MIACIDAE
— *Amphicticeps shackelfordi* Matthew & Granger, 1924a; seen by the authors in the collections at Warsaw

CANIDAE
— *Amphicynodon teilhardi* (Matthew & Granger, 1924a) Mellett, 1968; seen by the authors in the collections at Warsaw
(= *Cynodon teilhardi* Matthew & Granger, 1924a)

ORDER Indet.

DIDYMOCONIDAE
— *Didymoconus berkeyi*? Matthew & Granger, 1924a; seen by the authors in the collections at Warsaw

Lat. 45° 13′ N
Long. 94° 54′ E

Fig. 1, n° 6

MONGOLIA
GOBI ALTAY PROVINCE
Alag-Nur Basin

unnamed svita **middle Oligocene**

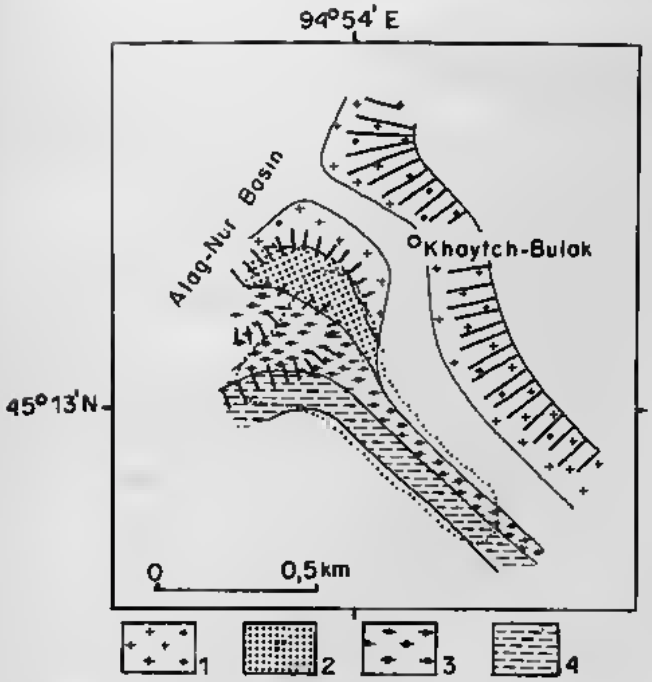
Locality: Khaytch

The minor locality of Khaytch[47] was also discovered by the Polish-Mongolian Expedition of 1964. It is situated at the eastern border of the Alag-Nur[48] Basin. Devyatkin worked here in 1965, 1970 and 1976.

The Tertiary sediments are differentiated into

47 Khaytch (= Khatch = Kaitch-Bulak) = scissors (scissors spring? separation spring?).
48 Alag-Nur (= Alak-Nur) = variegated (in color) lake.

Source : MNHN, Paris



three levels: the lower series, about 20 m thick, consists principally of light colored, coarse-grained sands; the middle level is red mudstone, and the upper beds are orange mudstones.

Collecting was poor, but lagomorphs, cricetid and ctenodactylid rodents and large mammal remains were found.

FIG. 185. — Sketch map of the locality of Khaytch, Mongolia. The area encircled by a dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. 1. crystalline rocks; Oligocene; 2. lower series; 3. central series; 4. upper series. Modified from Gradzinski *et al.*, 1968/1969.

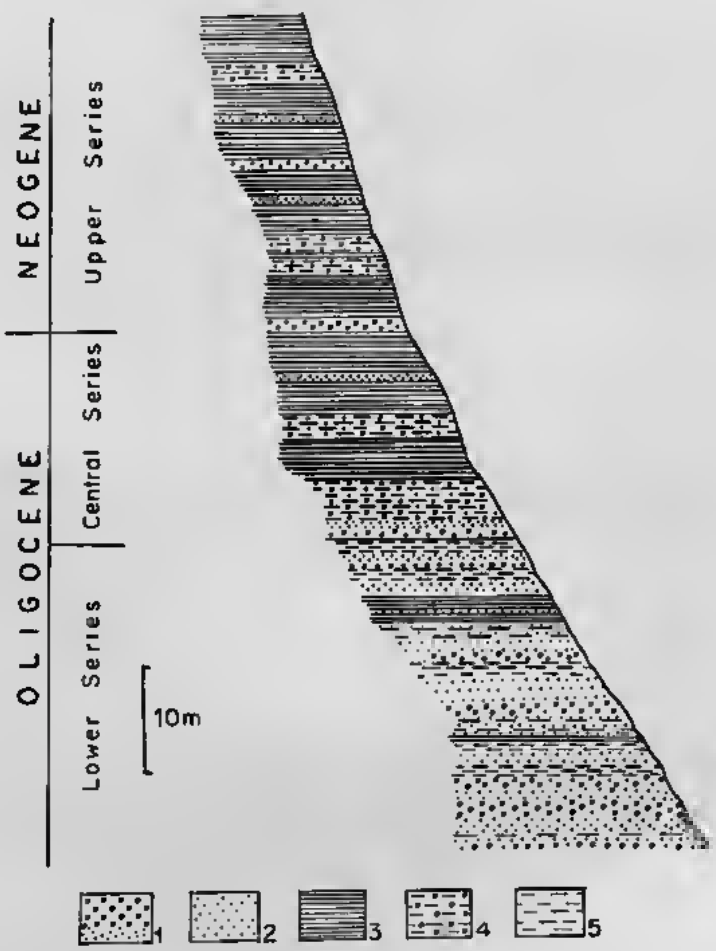


FIG. 186. — Geological profile of the Oligocene sediments at the Khaytch locality, Mongolia. 1. gravels; 2. sands; 3. mudstone or siltstone; 4. mudstone or mud with gravel; 5. silt. Modified from Gradzinski *et al.*, 1968/1969.

Source : MNHN, Paris

Fauna of the unnamed svita at Khaytch

LAGOMORPHA Indet.; cited by Kielan-Jaworowska & Dovchin, 1968/1969

RODENTIA

CRICETIDAE Indet.; cited by Kielan-Jaworowska & Dovchin, 1968/1969

CTENODACTYLIDAE — *Tataromys gobiensis* Kowalski, 1974

Lat. 44° 52′ N
Long. 97° 21′ E

Fig. 1, n° 5

MONGOLIA

GOBI ALTAY PROVINCE

unnamed svita **middle Oligocene**

Locality: Narin-Bulak

The exposures of this locality are situated in an intermontane basin 25 km WNW of the Ulan-Ganga site and about 3 km NW of the Narin[49] (or Zaram) Bulak swamp. The outcrops are formed in a poorly dissected escarpment, 6-8 m high, at the foot of the Kharaat-Ula Range; the sediment is a red mudstone.

The locality was discovered during a reconnaissance trip by members of the Polish-Mongolian Paleontological Expedition in 1964. Less than a day was spent at the site, which was rather poorly fossiliferous (though rich in live mosquitoes). However, small insectivores, lagomorphs and rodents (cylindrodontids, in particular) were collected and indicate a middle Oligocene age.

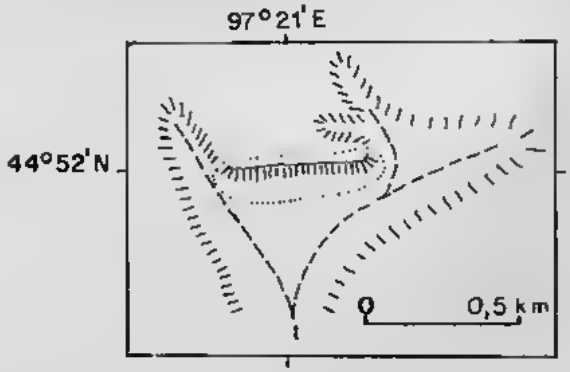


FIG. 187. — Sketch map of the Narin-Bulak locality, Mongolia. The area encircled by a dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968/1969.

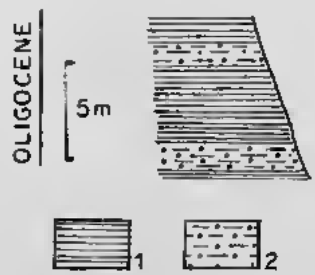


FIG. 188. — Geological profile of the Oligocene sediments at the Narin-Bulak locality, Mongolia. **1**. mudstone or siltstone; **2**. mudstone or mud with gravels. Modified from Gradzinski *et al.*, 1968/1969.

49 Narin-Bulak (= Nareen-Bulak = Zaram-Bulak) = narrow spring.

Source : MNHN, Paris

Fauna of the unnamed svita at Narin-Bulak

INSECTIVORA

ERINACEIDAE — *Amphechinus* cf. *minimus* (Bohlin, 1942); cited by Sulimski, 1968 (*Palaeoerinaceus* = *Amphechinus* in Sulimski, 1968)

INSECTIVORA Indet.; cited by Kielan-Jaworowska & Dovchin, 1968/1969

LAGOMORPHA

OCHOTONIDAE — *Desmatolagus gobiensis* Matthew & Granger, 1923d; cited by Sych, 1975

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974

APLODONTIDAE — *Prosciurus arboraptus* Shevyreva, 1971b; cited by Kowalski, 1974

CRICETIDAE — *Eucricetodon asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977 (= *Eumys asiaticus* Matthew & Granger, 1923d; cited by Kowalski, 1974)

CTENODACTYLIDAE — *Tataromys sigmodon* Matthew & Granger, 1923d; cited by Kowalski, 1974

Lat. 44° 40′ 30″ N
Long. 97° 31′ 30″ E

Fig. 1, n° 7

MONGOLIA

GOBI ALTAY PROVINCE

unnamed svita **middle Oligocene**

Locality: Ulan-Ganga

A reconnaissance team of the Polish-Mongolian Paleontological Expedition of 1964 discovered in the Western Gobi Desert, south of the Gobi Altai Range, a fossiliferous outcrop of a very vivid red sand and sandstone that covered approximately 25 square kilometers. These sediments contained numerous remains of small mammals, mostly rodents; a sampling was obtained during 6 hours of surface collecting.

The Ulan-Ganga[50] exposures are situated in an intermontane basin, about 92 km ESE from the settlement of Dzahooy. They extend along the lowest part of the basin near the southern margin of a ridge named Khayrkhan-Ula. The outcrops are in erosional escarpments about 10 m high cut into the surface of the sediment and the sharp crested hills. Locally, intercalations of gray, poorly cemented sandstone and a conglomerate with limestone concretions are present in the red mudstones.

In the lower part of the exposures larger mammal bones were found. On the basis of a specimen of *Eggysodon* it has been suggested that the age of the locality might be slightly younger than that of the Shand-Gol Svita.

50 Ulan-Ganga = red outcrop.

Source : MNHN, Paris

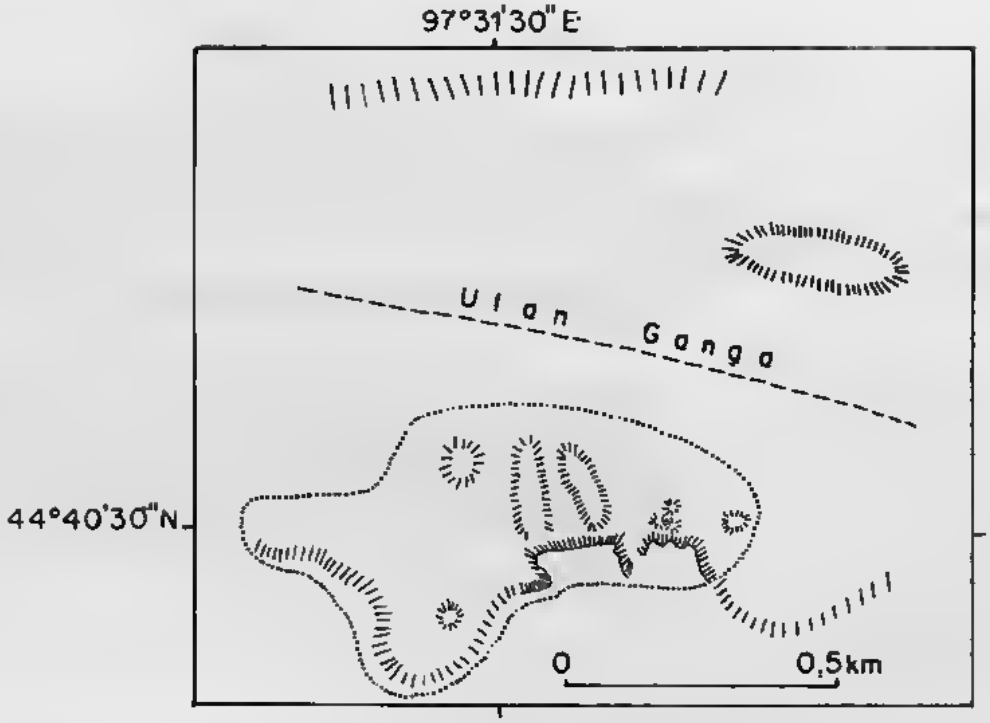


FIG. 189. — Sketch map of the Ulan-Ganga locality, Mongolia. The area encircled by a dotted line indicates the limit of the surface that was prospected for fossils by the Polish-Mongolian Expedition of 1964. Modified from Gradzinski *et al.*, 1968/1969.

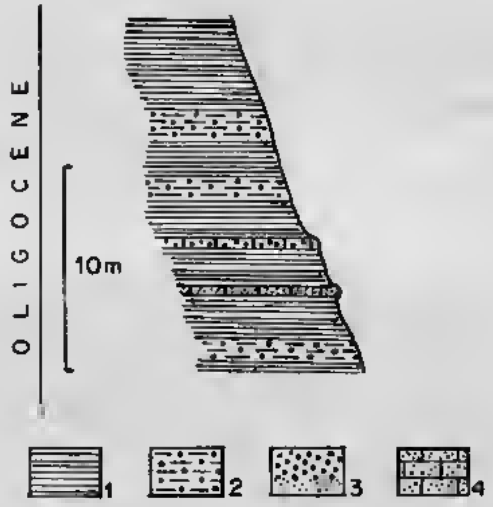


FIG. 190. — Geological profile of the Oligocene sediments at the Ulan-Ganga locality, Mongolia. Most of the section is composed of mudstone (1), with a bed of gravelly mudstone (2) near the bottom, followed by a thin sandstone (4) layer, a conglomerate (3) layer, and then two more levels of gravelly mudstone. Modified from Gradzinski *et al.*, 1968/1969.

Fauna of the unnamed svita at Ulan-Ganga

LAGOMORPHA

OCHOTONIDAE — *Desmatolagus gobiensis* Matthew & Granger, 1923d; cited by Sych, 1975

RODENTIA

TSAGANOMYIDAE — *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Kowalski, 1974

Source : MNHN, Paris

APLODONTIDAE — *Prosciurus lohiculus* Matthew & Granger, 1923d; cited by Kowalski, 1974

CTENODACTYLIDAE — *Karakoromys decessus* Matthew & Granger, 1923d; cited by Kowalski, 1974

PERISSODACTYLA

RHINOCEROTIDAE — *Eggysodon minor* (Belyayeva, 1954c) Brunet, 1979
(= *Allacerops turgaica minor* Belyayeva, 1954c)
(= *Allacerops minor* (Belyayeva, 1954c); cited by Borsuk-Bialynicka, 1968/1969)

ARTIODACTYLA Indet. (2 forms) seen in the collection at Warsaw by the authors.

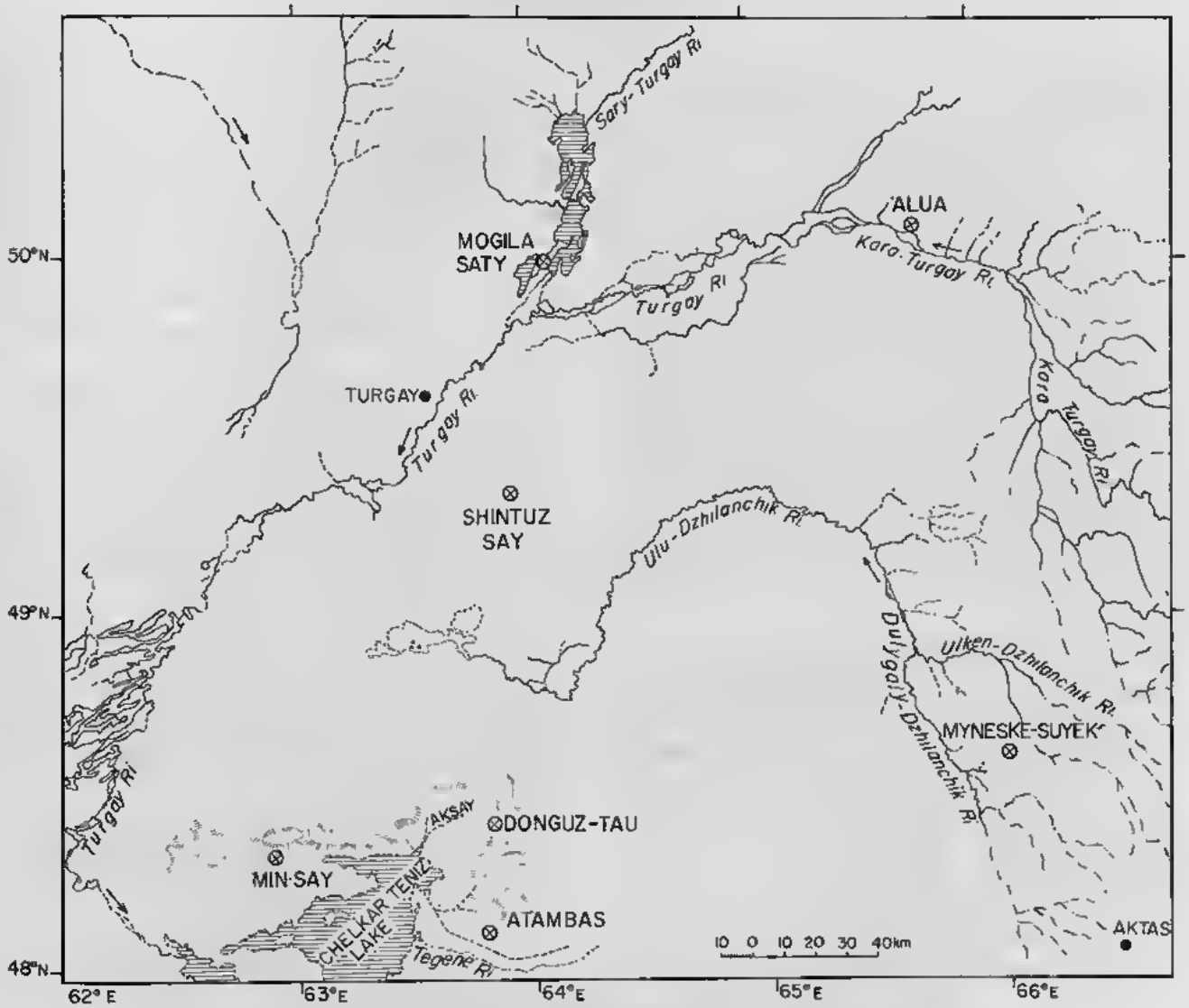


FIG. 191. — Due to inadequate maps and conflicting or incomplete information, the geographical situation of the fossil localities indicated in the Turgay region of the Kazakh S.S.R. can only be termed approximate.

From Atambas Chink, through Donguz-Tau Chink, Ak-Say Ravine, and along the cliffs into the Myn-Say area (which includes Kur-Say Ravine), the whole northern limit of Chelkar-Teniz Lake is apparently fossiliferous.

The Myneske-Suyek area includes the Dulygaly-Dzhilanchik region, with Tort-Mola, and extends along the banks of the Dumaly-Dzhilanchik (up to 15 km to the SSE) and the Kulebay-Baksy-Dzhilanchik (25 km to the SE) Rivers; to the southwest, the Sary-In Chink locality, 30 km distant, is also considered part of the area. The same fossil bearing beds crop out at Alua, on the banks of the Kara-Turgay River.

The Saty tomb, of equivalent age, is placed, approximately, near the Sary-Turgay River. Also of middle Oligocene age, the ravine of Shintuz-Say, near Lake Shintuz, is said to be located 40 km SE of the town of Turgay. Modified from maps provided by G. V. Shkurkin..

Source : MNHN, Paris

Lat. 48° 20′ N, approx.
Long. 63° 15′ E, approx.

Fig. 3, n° 21

U.S.S.R.
Kazakh S.S.R.
Aktyubinsk Oblast'

Chilikty Svita **middle Oligocene**
Locality: Chelkar-Teniz

The richly fossiliferous area near the shores of Lake Chelkar-Teniz[51] was discovered in 1912 by the geologist Gaylit. This was to be the first of the famous indricothere fauna localities. Collections were made by the Imperial Academy of Sciences in 1913 by Gaylit, in 1914 by Kozlov, in 1915-1916, and 1924 by Bayarunas and Prokhorov, in 1926 by Belyayeva and Prokhorov, and in 1941 by Orlov. The collecting was done principally in the cliffs (Atambas Chink[52], Donguz-Tau Chink[53], Mashay Chink) and ravines (Kur-Say[54], Myn-Say[55], Dzhualy-Say[56], Ak-Say[57], and others) situated to the north and east of the lake. Some of these sites have been treated as separate localities (for example, Atambas Chink, found in 1939 by Petrushevskiy, and Donguz-Tau, found by Orlov's 1941 expedition), but they are all considered here as representing a single fauna.

One of the more complete sections of the "Indricothere" Svita, and one containing a series of bone-bearing lenses, is found in the area of the Kur-Say Ravine, on the northwestern edge of Lake Chelkar-Teniz, on or near Chelkar-Nura[58]. From here came the bones of the *Indricotherium* that was first described by Borisyak (1915, 1923) and who coined the name indricothere beds. The numerous excavations that have been carried out here by paleontologists of the Academy of Sciences of the U.S.S.R. fully justify this area's reputation as representing the classical locality of the indricothere fauna.

Lateral equivalents of the indricothere beds have received many names. In the Turgay area the "Indricothere" Svita is usually called the Chilikty[59] Svita; to the southwest, along the Sary-Su River, the name Boktykaryn Svita dominates, at least according to Dmitriyeva and Nesmayanov (1982) who synonymize with the latter the terms Kenderlyk, Kyzylkol', and Bet-pakdal; Kuranbulak can also be considered a synonym.

To the west of Lake Chelkar-Teniz light, fine sandy rocks predominate; clays are subordinate to the basic mass of sands and lie within them as lenses. As one moves to the east the sand component decreases in importance and clays begin to dominate. Also the sediments become increasingly red outside the Turgay region with this color typifying the "Indricothere" Svita to the south and southeast, to the Bet-Pak-Dala Steppe and southern Kazakhstan. The same replacement of the indricothere sands by clays to the east was observed by Lavrov in 1947-1948 in the exposures of the Ulu-Dzhilanchik and Ulkun-Dzhilanchik Rivers.

A composite section taken from the cliffs at Lake Chelkar-Teniz can be expressed as follows; the red color and clays are already dominant:

4. The Turgay Svita.
3. The upper member of the Chilikty Svita (= "Indricothere" Svita) is incompletely devel-

51 Chelkar-Teniz (= chalkar = shalkar) (= lengis = lengiz) = vast lake.
52 Atambas = cliff (chink) of My-Father Mountain.
53 Donguz-Tau = wild boar mountain.
54 Kur-Say = dry stream bed.
55 Myn-Say = a thousand ravines.
56 Dzhualy-Say = wild onion ravine.
57 Ak-Say = white dry stream bed (or ravine).
58 Chelkar-Nura (nura = mesa).
59 Chilikty = conforming to the custom.

Source : MNHN, Paris

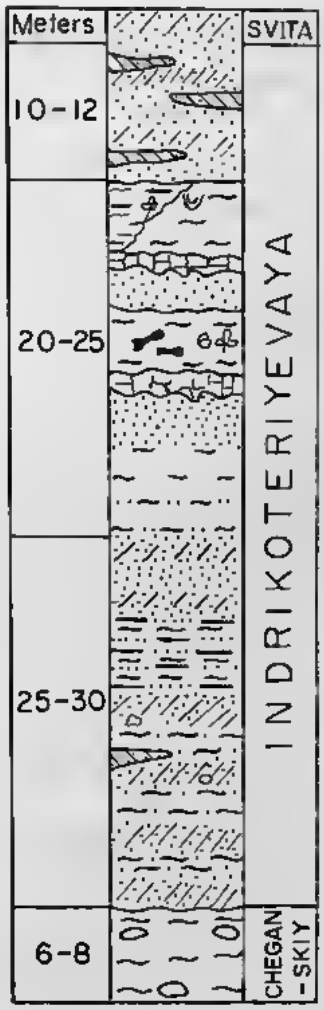


FIG. 192. — Schematic section of the Indricothere Svita at Chelkar-Teniz, (Kur-Say Ravine), Kazakh S.S.R. All but the bottom 6-8 meters (the Chegan clays with marly inclusions) are referable to this unit. At the top (10-12 m) is a sandy bed composed of light colored sand with abundant intercalations of ferruginous sandstone. In the middle (10-25 m) is the fossiliferous clay bed of green clay, sometimes gypsiferous, followed by marls and light colored sands; it contains the *Indricotherium* fauna, fresh water mollusks and a flora. At the base (25-30 m) are sandy-siltic beds, composed of light colored sand with ferruginous sandstone; it includes a narrow band of carbonaceous siltite, with limonite and ferruginous sandstone. The lithographic interpretations are those of Lavrov, 1959; drawing modified.

oped due to erosion; there is usually, but not always, an unconformity with the Turgay Svita. Fine grained, silty sands constitute the principal element and sandstone lenses are frequent. The limit with the underlying member is rather indistinct.

2. The lower member is predominantly green clay. It is of variable constituency, sometimes sandy, and sometimes with lenses up to 2 m thick of brick red and brownish red clays. Toward the bottom of the member, the sand element decreases. Mammal and fish bones litter the talus slopes of this member.

1. The Chegan Svita, with a sharp unconformity, underlies the "Indricothere" Svita (see Lavrov and Panova, 1984, for a review of the stratigraphy of the Turgay region).

As an important number of its faunal elements link Chelkar-Teniz with the middle Oligocene fauna of Shand-Gol, we feel that the two mammalian assemblages represent, approximately, the same period in geologic time.

Fauna of the Chilikty Svita at Chelkar-Teniz

RODENTIA

TSAGANOMYIDAE

— *Cyclomylus turgaicus* (Vinogradov & Gambaryan, 1952) Shevyreva, 1976
(= *Pseudotsaganomys turgaicus* Vinogradov & Gambaryan, 1952)

Source : MNHN, Paris

CASTORIDAE	— *Propalaeocastor habilis* Borisoglebskaya, 1967
	— *Palaeocastor* aff. *nebrascensis* Leidy, 1876; cited by Shevyreva, 1976
APLODONTIDAE	— *Plesiospermophilus* sp., *in* Schmidt-Kittler & Vianey-Liaud, 1979 (= *Plesiospermophilus lohiculus* (Matthew & Granger, 1923d); cited by Shevyreva, 1976)
CRICETIDAE	— *Cricetops aeneus* Shevyreva, 1965
	— *Cricetops dormitor* Matthew & Granger, 1923d; cited by Shevyreva, 1976 (= *Cricetops affinis* Argyropulo, 1938, *in* Shevyreva, 1965)
CTENODACTYLIDAE	— *Woodomys chelkaris* Shevyreva, 1971b (= *Woodromys chelkaris* Shevyreva, 1968, *nomen nudum*)
	— *Terraboreus*[60] *arcanus* Shevyreva, 1971b
CARNIVORA	
CANIDAE	— *Cynodictis minor* Yanovskaya, 1970
CREODONTA	
HYAENODONTIDAE	— *Hyaenodon dubius* Filhol, 1873; cited by Gromova, 1952a (= *Hyaenodon aymardi* Filbol, 1882, *in* Lange-Badré, 1979)
PERISSODACTYLA	
CHALICOTHERIIDAE	— *Schizotherium turgaicum* Borisyak, 1920
	— *Schizotherium chucuae* Gabunia, 1951; cited by Belyayeva, 1954b
HELALETIDAE	— *Colodon orientalis* Borisyak, 1918
HYRACODONTIDAE	— *Ardynia kazachstanensis* (Belyayeva, 1952) Radinsky, 1967 (= *Parahyracodon kazachstanensis* Belyayeva, 1952) (= *Ergilia kazachstanica* Gromova, 1960b)
	— *Triplopus*? *turgaiensis* (Belyayeva, 1954a) Radinsky, 1967 (= *Prothyracodon turgaiensis* Belyayeva, 1954a)
	— *Indricotherium transouralicum* Pavlova, 1922 (= *Indricotherium asiaticum* Borisyak, 1923, *in* Gromova, 1959) (= *Indricotherium minus* Borisyak, 1923, *in* Gromova, 1959)
RHINOCEROTIDAE	— *Eggysodon turgaicus* (Borisyak, 1915) Brunet, 1979 (= *Epiaceratherium turgaicum* Borisyak, 1915) (= *Allacerops turgaica* (Borisyak, 1915) Radinski, 1967)
AMYNODONTIDAE	— *Cadurcodon*? sp.; cited by Belyayeva, 1970
ARTIODACTYLA	
ENTELODONTIDAE	— *Entelodon diconodon* Trofimov, 1952b (= *Entelodon* sp., *in* Brunet, 1979; specifically indeterminate)
ANTHRACOTHERIIDAE	— *Hemimeryx turgaicus* Borisyak, 1941
	— *Brachyodus* sp.; cited by Flerov *et al.*, 1974
	— *Hyoboops* sp.; cited by Flerov *et al.*, 1974; questionably cited by Flerov & Yanovskaya, 1971
SUIDAE	— *Propalaeochoerus* sp.; cited by Flerov & Yanoskaya, 1971
GELOCIDAE	— *Lophiomeryx turgaicus* Flerov, 1940
	— *Prodremotherium flerowi* Trofimov, 1957
ORDER Indet.	
DIDYMOCONIDAE	— *Didymoconus colgatei* Matthew & Granger, 1924a (= *Tshelkaria rostrata* Gromova, 1960a, *in* Mellett, 1968)

60 According to Wood, 1977, *Terrarboreus* and *Woodomys* may be synonymous.

Source : MNHN, Paris

Lat. 49° 20′ N, approx.
Long. 63° 55′ E, approx.

Fig. 3, n° 20

U.S.S.R.
KAZAKH S.S.R.
TURGAY OBLAST'
Turgay Depression

Chilikty Svita **middle Oligocene**
Locality: Shintuz-Say

In the sands of the "Indricothere" Svita, 40 km to the southeast of the town of Turgay, remains of the indricothere fauna were collected in the gully of the Shintuz-Say[61] River which flows north into the lake of the same name 4-5 km distant. Here, in cliffs 12-14 m high, in the sands and silts of the lower part of the svita and in the middle part of the gully, were found skeletons of *Indricotherium* (by Borovikov in 1946) and of "*Pristinotherium*" (by Biryukov in 1948). A flora was also discovered in this site, according to Lavrov, 1959.

Fauna of the Chilikty Svita at Shintuz-Say

RODENTIA

TSAGANOMYIDAE

— *Cyclomylus turgaicus* (Vinogradov & Gambaryan, 1952) Shevyreva, 1976
(= *Pseudotsaganomys turgaicus* Vinogradov & Gambaryan, 1952)

PERISSODACTYLA

HYRACODONTIDAE

— *Indricotherium transouralicum* Pavlova, 1922; cited by Flerov *et al.*, 1974
— *Indricotherium brevicervicale* (Biryukov, 1953)
(= *Pristinotherium brevicervicale* (Biryukov, 1953); considered *nomen nudum* in Flerov *et al.*, 1974)
— *Ardynia kazachstanensis* (Belyayeva, 1952) Radinsky, 1967
(= *Parahyracodon kazachstanensis* Belyayeva, 1952)
(= *Ergilia kazachstanica* Gromova, 1960b); cited by Flerov & Yanovskaya, 1974

61 Shintuz-Say = real salt ravine.

Source : MNHN, Paris

Lat. 50° N, approx.
Long. 64° 3′ E, approx.

Fig. 3, n° 19

U.S.S.R.
KAZAKH S.S.R.
Turgay Oblast'

Chilikty Svita **middle Oligocene**
Locality: Mogila-Saty

On the right bank of the Sary-Turgay River, east of Mogila-Saty[62] and 19 km above the confluence of the Sary-Turgay and Kara-Turgay Rivers, Biryukov in 1948 discovered a skeleton of *Indricotherium* and bones of *Anthracotherium*. Their stratigraphic implications were of importance for the region.

The *Indricotherium* was found lying on its side in the middle part of a bed of yellow buff clays having a thickness of 20 m. Along with the giant adult remains, the jaw of a juvenile individual was also discovered. The conditions of burial indicate that very little or no transport had been involved.

Fauna of the Chilikty Svita at Mogila-Saty

PERISSODACTYLA
HYRACODONTIDAE — *Indricotherium transouralicum* Pavlova, 1922 (= *Indricotherium asiaticum* Borisyak, 1923, *in* Gromova, 1959; cited by Lavrov, 1959)

ARTIODACTYLA
ENTELODONTIDAE Indet.; cited by Lavrov, 1959 (=? *Anthracotherium*, found by Biryukov)

Lat. 50° 4′ N, approx.
Long. 65° 40′E, approx.

Fig. 3, n° 18

U.S.S.R.
KAZAKH S.S.R.
Turgay Oblast'

Chilikty Svita **middle Oligocene**
Locality: Alua

The ravines of Alua[63], a place-name in the middle course of the Kara-Turgay[64] River at the eastern margin of the Turgay region, have furnished the remains of indricotheres. Surface collections were made in 1912 by Matveyev, in 1920 by Vassil'yevskiy and by Bayarunas and Prokhorov in 1924. At Alua the river forms an embankment, or small cliff, 11 m high in which a

62 Mogila Saty = Tomb of Saty.
63 Alua = a Mohammedan saint.
64 Kara-Turgay = starling, or black lark.

Source : MNHN, Paris

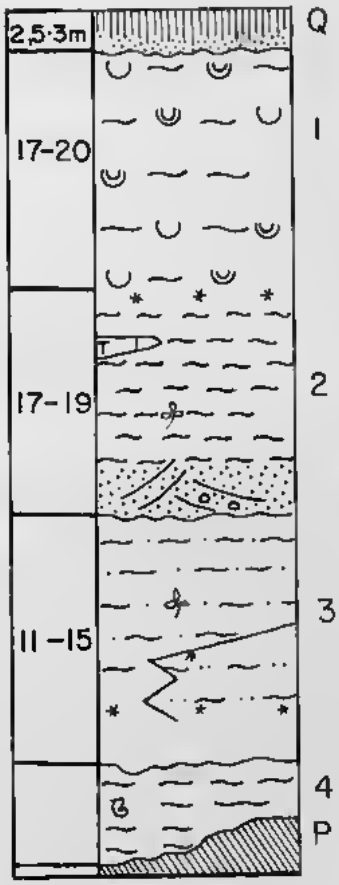


FIG. 193. — The section along the Zhamankaindy River, Kazakh S.S.R. Q: argillaceous and sandy Quaternary terrain. 1. The Neogene Aral' Svila; principally green clay with salt and gypsum concretions; 2. The Turgay Svita; at the top, green clay with ferruginous stringers; white and variegated siltite with paleosols and a broad leaved flora; at the bottom, compact, white, crossbedded sand; 3. Indricothere Svita; yellow and brownish sandy clay and silt with a xenophylic flora; yellow and brown clay and argillaceous sand with thin ferruginous intercalations; 4. Chegan Svita; marine clays with mollusks. P: Paleozoic bedrock. The lithostratigraphic interpretations are those of Lavrov, 1959; drawing modified.

stratigraphic succession could be observed and through which the above-mentioned ravines cut. A little way downstream from the cliff, where the river turns south, an extensive surface of clay (bed n° 1 in the section below) is exposed at water level. On this surface were found partially exposed indricothere bones. Fossils of the Kara-Turgay region are black (in contrast to those, contemporary, from Chelkar-Teniz) and are often partially enclosed in concretions. Furthermore, only isolated remains are known from here, no associated skeletons. Bayarunas (1936) recommended that further research could be made profitably both at Alua and downstream along the Kara-Turgay River.

The section at Alua is the following:

10. loessic deposit

9. quartzitic white sand
8. iron concretionary layer
7. quartzitic white sand
6. thin, compact ferruginous (rusty red) layer
5. yellowish brown clay with compact, ferruginous intercalations
4. same clay, without intercalations
3. sandy, gray green clay
2. concretionary, rusty brown layer
1. sandy, gray green clay

In the beds n° 3 and 1 much marcasite occurs, along with plants, carbonized tree trunks, numerous internal molds of unios, and the vertebrate remains. Pavlova considered the indricothere bones collected here to belong to two different species, *I. asiaticum* and *I. transouralicum*, but the former was synonymized with the latter by Gromova (1959)

Fauna of the "Indricothere" Svita at Alua

PERISSODACTYLA

HYRACODONTIDAE

— *Indricotherium transouralicum* Pavlova, 1922
(= *Indricotherium asiaticum* Borisyak, 1923, *in* Gromova, 1959)

Source : MNHN, Paris

Lat. 48° 40′ N, approx.
Long. 66° E, approx.

Fig. 3, n° 17

U.S.S.R.
KAZAKH S.S.R.
Dzhezkazgan Oblast'
Ulutau Rayon
Dzhilanchik Basin

Chilikty Svita **middle Oligocene**
Locality: Myneske-Suyek

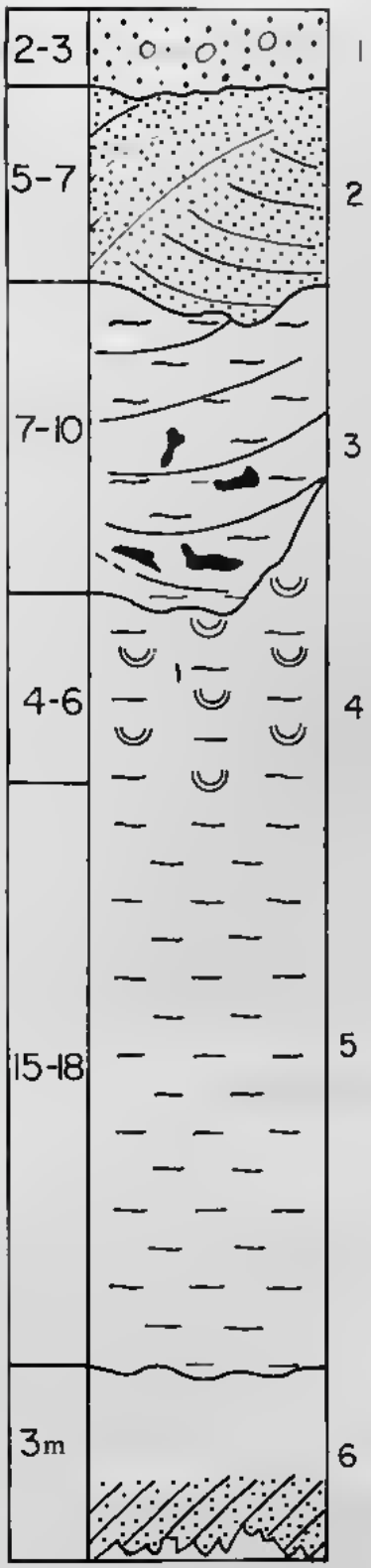
The Myneske-Suyek[65] locality was discovered in 1947 by Lavrov and Bazhanov about 85 km north of Baykonur[66] during a paleontological expedition through the southeastern part of the Turgay Depression organized by the Academy of Sciences of the Kazakh S.S.R. The rich bone-producing area was found near the workshops of a manganese mine, 8 km east of the Tort-Mola[67] mosque and 6 km to the northeast of the valley of the Dumaly-Dzhilanchik[68], a right tributary of the Dulygaly[69] River. The bone-bearing bed at Myneske-Suyek (as it is usually spelled in recent Soviet literature) is widely distributed on the right bank of the Dulygaly and can be followed 10-15 km to the SSE up the valley of the Dumaly (or Ashaly[70]) River. The amount of bone is somewhat less this far from the principal locality, but still impressive; a large and completely preserved entelodont skull was collected here by Biryukov in 1954. Other vertebrate remains have been recorded from the hill known by its altitude of 306 m (15 km SE of Myneske-Suyek) and along the cliffs of the right bank of the Kulebay-Baksy-Dzhilanchik River, 25 km SE of Myneske-Suyek. The so-called Dulygaly-Dzhilanchik site is often treated as separate locality, due to the importance of the fossils found there, but its individuality with respect to other localities in the region is not clear.

Throughout the eastern part of the Turgay Depression the complex of lagoonal and continental Oligocene beds are underlain by a characteristic sheet-like bed of gray green clays, varying from 5 to 18 m in thickness. These clays are correlated with the marine Chegan Svita, well known in the area northwest of the Aral Sea. The lower fossiliferous member at Myneske-Suyek is composed of dense clays of variable thickness due to erosion after their deposition; at Myneske-Suyek they comprise 4-6 m but at Saryin-Chink[71], 30 km to the SW, their maximum thickness is 40 m. Lavrov and Bazhanov (1948) considered this bed to occupy a transitional position between the bone-bearing clays of the Chilikty Svita at the eastern margin of the Turgay Depression and the bone-producing beds at Lake Chelkar-Teniz. At Myneske-Suyek the principal bone level lies on the eroded surface of the dense clays. Numerous concretions of iron and manganese accompany the bones.

The section at Myneske-Suyek has been described by Lavrov and Bazhanov (1948) and Lavrov (1959); briefly it is as follow:

65 Myneske-Suyek (= Myn-Eskesuek = Myneske-Suïek = Myngeski-Suyak): name proposed by Lavrov and Bazhanov (1948) meaning, in translation from the Kazakh, one thousand ancient bones; it is apparently not a place-name.
66 Baykonur = two possible meanings: a brown or gray-brown man (a man can be referred to as black when he is greedy; a brown or gray-brown man might mean that he was not too honest); the other meaning could be the place where rich people camp.
67 Tort-Mola (= Tort Molla) = four tombs.
68 Dumaly-Dzhilanchik (= Dumaly-Zhilanchik, or Djilancik).
69 Dulygaly (= Dulygaly-Dzhilanchik) = helmeted little snake.
70 Ashaly = forked.
71 Saryin (= Sary-In) = yellow grotto.

Source : MNHN, Paris



Turgay Svita	— light colored sands	5-7 m
"Indrico-there"	— clays with increasingly fewer fossil bones toward the top	up to 6 m
	— bone-bearing bed; sandy clay with much fossil bone disseminated throughout its thickness	4 m
Svita	— dense clays (the Sary-In Svita of Lavrov and-Bazhanov, 1948)	6 m
	— silts	1 m
Chegan Svita	— marine clays	18 m

An interdisciplinary decision reached at a meeting in Alma-Ata [72] in 1967 decreed that both Myneske-Suyek and Kyzyl-Kak and the beds that include them should be considered early Oligocene in age. Comparison of their mammalian faunas on an international scale, however, indicates that a middle Oligocene age is more compatible with the known data. Such Soviet workers as Shevyreva (1976) and Biryukov (1977) also continue to refer to them as middle Oligocene.

FIG. 194. — Schematic section at Myneske-Suyek, Kazakh S.S.R. 1. Quaternary gravelly, compact, yellow brownish sand; 2. fine grained, white, crossbedded, compact sand with rare fragments of bone; 3. sandy clay bed with the bones of mammals and turtles; 4 reddish brown gypsiferous clay with rare elements of the terrestrial and marine fauna; 5. gray-green Chegan marine clay; 6 lacuna in the sequence; presence of an eolian erosional crust. The bedrock is a Paleozoic sandstone. Modified from Lavrov & Bazhanov, 1948.

72 Alma-Ata is a Russian adaptation of the Kazakh Almaty, meaning apple orchard.

Source : MNHN, Paris

Fauna of the "Indricothere" Svita at Myneske-Suyek

RODENTIA

TSAGANOMYIDAE — *Cyclomylus turgaicus* (Vinogradov & Gambaryan, 1952) Shevyreva, 1976
(= *Pseudotsaganomys turgaicus* Vinogradov & Gambaryan, 1952)

CYLINDRODONTIDAE — *Ardynomys? kazachstanicus* Vinogradov & Gambaryan, 1952

CASTORIDAE — *Agnotocastor aubekerovi* Lychev, 1978
(= *Agnotocastor aubekerovi* Kostenko *et al.*, 1971, *nomen nudum*)

CREODONTA

HYAENODONTIDAE — *Hyaenodon dubius* Filhol, 1873
(= *Hyaenodon aymardi* Filhol, 1882, *in* Lange-Badré, 1979; cited by Flerov *et al.*, 1975)

PERISSODACTYLA

CHALICOTHERIIDAE — *Schizotherium turgaicum* Borisyak, 1920; cited by Belyayeva, 1954b

HELALETIDAE — *Colodon orientalis* Borisyak, 1918; cited by Gromova, 1960b

HYRACODONTIDAE — *Indricotherium transouralicum* Pavlova, 1922; cited by Flerov & Yanovskaya, 1971
— *Indricotherium brevicervicale* (Biryukov, 1953)
(= *Pristinotherium brevicervicale* Biryukov, 1953); considered *nomen nudum* in Flerov *et al.*, 1974
— *Ardynia kazachstanensis* (Belyayeva, 1952) Radinsky, 1967
(= *Parahyracodon kazachstanensis* Belyayeva, 1952; cited by Belyayeva, 1954)
(= *Ergilia kazachstanica* Gromova, 1960b)

RHINOCEROTIDAE — *Eggysodon turgaicus* (Borisyak, 1915) Brunet 1979
(= *Epiaceratherium turgaicum* Borisyak, 1915; cited by Lavrov & Bazhanov, 1948)
(= *Allacerops turgaica* (Borisyak, 1915) Belyayeva, 1954c)

AMYNODONTIDAE — *Cadurcodon kazakademius* Biryukov, 1961b

ARTIODACTYLA

ENTELODONTIDAE — *Entelodon major* Biryukov, 1961a

TRAGULIDAE Indet.; cited by Musakulova, 1971

Flerov and Yanovskaya (1971) noted (repeated in Flerov *et al.*, 1974) that in the minor "late" Oligocene localities of Kutantas[73], Belyeuty[74], Bollotam[75] Saroy and Tasbulak the fossil mammalian remains discovered were isolated and very fragmentary. In the first three of the sites only unidentified "indricotheriids" were found. Surprisingly, they propose a possible middle Oligocene age for the latter two. Bazhanov (1962) and Kostenko *et al.* (1971) published faunal lists that are rather more extensive than theirs[76] from Sary-Su (but the mesa Tasbulak is not mentioned, which might indicate that Sary-Su includes an area greater than just Tasbulak)

73 Kulantas = stork rock; it is situated near the western limit of the Bel-Pak-Dala (which must be near the Sary-Su River).

74 Belyeuly is situated on the river of the same name (see Birzhenok-Say).

75 Bolottam = wall of steel (also called Mogila (tomb) Bolottam); it is found in the region of the headwaters ("upper course") of the Ulu-Dzhilanchik River, and therefore should be somewhere in the Myneske-Suyek area. Lavrov (1959) cited Bolattam (*sic*) on the right bank of the Dulygaly-Dzhilanchik River. Nikiforova (1960) briefly described the locality as being on the southern part of the Dzhilanchik River, near Mogila Bolottom. In the lowest part of what Lavrov has termed the Turgay Svita, Nikiforova in 1954, accompanied by other geologists, found a partial skeleton of a gigantic rhinoceros. Apparently the same beds were regarded as extending to Myneske-Suyek.

76 "Indricotheriidae indet. and Hyracodontidae indet.".

Source : MNHN, Paris

and clearly consider it to represent the middle Oligocene indricothere assemblage. Saroy has been correlated with the late Oligocene Askazansor Svita and this seems hardly questionable. Thus, we wonder that the Sary-Su locality could be regarded as possible late Oligocene and that Saroy could be doubted as late Oligocene.

Only unidentified "indricotheriids" were found in the first three localities and it is likely that they also represent the middle Oligocene indricothere fauna. Mogila Bolottam is relatively close to the middle Oligocene site of Myneske-Suyek and Belyeuty is near the middle Oligocene site of Kyzyk-Kak. The indricothere fauna also occurs to the south of the latter in the supposed region of Kutantas.

Flerov and Yanovskaya (1971) also mention as "late" Oligocene sites the ravine Birzhenok[77] Say (situated near Mogila Bolottam), Boktykaryn, Sary-Ozek Station and the Ozhungarian Alatau. Boktykaryn is usually associated with the middle Oligocene Sary-Su locality; this may imply that one site exists along the Boktykaryn River, but, in any case, we know of no late Oligocene fauna from this region. Sary-Ozek Station and the Dzhungarian Alatau are probably mostly of late Oligocene aga.

The age of Ashutas could be early Miocene, according to Flerov and Yanovskaya (1971), but they regard it as late Oligocene. Not knowing what was found there, we have no opinion.

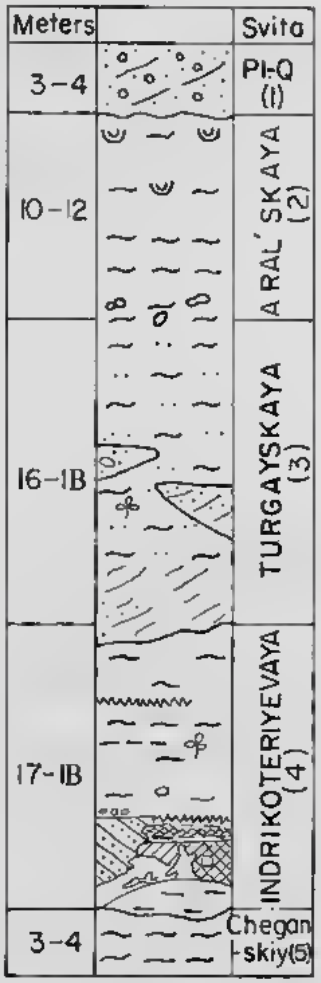


FIG. 195. — Section on the Dulygaly River in the Bolottam (Akmola) area, Kazakh S.S.R. 1. Pleistocene and Quaternary gravelly sands; 2. Aral' Svita; green clays with salt and gypsum; 3. Turgay Svita; light colored compact silt with lenses of obliquely stratified sand containing leaf impressions; light colored compact sand with oblique sedimentation; 4. Indricothere Svita; at the top; mineral excrescences (sulphur, etc.) and a lens of oolitic iron; compact gray clay with intercalations containing humus and a flora; at the bottom is a carbonaceous member, passing laterally into a facies of ferruginous sandstone with siderite; 5. Chegan marine clays. Lithostratigraphic interpretations are those of Lavrov, 1959; drawing modified.

77 Birzhenok-Say: a ravine situated on the Belyeuty River; the two names stand for the same locality.

Source : MNHN, Paris

Lat. 45° 34′ N, approx.
Long. 67° 20′ E, approx.

Fig. 3, n° 15

U.S.S.R.
KAZAKH S.S.R.
Chimkent Oblast'

Betpakdaka Svita **middle Oligocene**
(= Boktykaryn Svita)
(= Kenderlyk Svita)
Locality: Sary-Su

In the large cliff (50-60 m high) that stretches approximately north-south along the left bank of the Boktykaryn[78] River, remains of the indricothere fauna were collected by Belyayeva and Prokhorov in 1927, by Kashkarova in 1929, by Orlov in 1936, by Bolin in 1946 and by Kostenko and Timush (near Akinakul') in 1955. At the erosional remnant called Tas-Bulak[79], across the river from the tomb (mogila) Ala-Tage[80] and about 30 km SW of Kzyl-Dzhingil[81], a locality has been designated. It is usually called Sary-Su but is also combined with other local names, such as Sary-Su (Tasbulak) or Sary-Su — Boktykaryn. Actually, collections were apparently made from a series of points in the area (see Fig. 214, p. 375).

The exact location of the section given here (from Orlov, 1941) is uncertain, but from the routes followed by Orlov's expedition it is probably not from the Boktykaryn cliffs, where the Askazansor Svita is well exposed (up to 160 m) and would probably overlie the levels 2 and 3 presented below. An unconformity is said by Dmitriyeva and Nesmeyanov (1982) to exist here between the Askazansor Svita and the Boktykaryn[82], as well as another that separates the latter from the underlying Chegan Svita.

Section along the Sary-Su River (west Bet-Pak-Dala)

5. top soil ..... 10-40 cm
4. sands, middle to coarse grained, often without distinct bedding; concretionary sandstone tubes in bottom part; probably continental. ..... 2-4 m
3. brick red clays, sometimes with bright green patches; occasionally gypsiferous; continental. ..... up to 30 m or more
2. gray green clays, sometimes blueish or yellowish; gypsiferous; marine..... ..... 60-90 m or more
1. greenish sands with oysters and sharks; littoral; does not crop out.

Flerov *et al.* (1974) have cited the Sary-Su locality as being of late Oligocene age, but since *Cricetops dormitor, Schizotherium turgaicum* and *Lophiomeryx turgaicus* all typify the middle Oligocene Chelkar-Teniz fauna, we prefer to consider this locality as part of the same assemblage.

78 Boktykaryn (= Bokty-karyn = Baktykaryn = Bokhtykaryn) (= Dzheman-Su (= evil water) in Orlov, 1941).
79 Tas-Bulak (= Tasbulak = Tes-Bulak) = rocky spring.
80 Ala-Tage = diverse colors (+ tage).
81 Kzyl-Dzhingil = red tamarisk.
82 Dmitreyeva and Nesmeyanov (1982) prefer the svita name of Boktykaryn to that of the Kenderlyk Svita.

Source : MNHN, Paris

Fauna of the Betpakdala Svita at Sary-Su

RODENTIA

CRICETIDAE — *Cricetops* cf. *dormitor* Matthew & Granger, 1923d; cited by Kostenko *et al.*, 1971

CARNIVORA Indet.; cited by Bazhanov, 1962

CREODONTA

HYAENODONTIDAE — *Hyaenodon* sp.; cited by Bazhanov, 1962

PERISSODACTYLA

CHALICOTHERIIDAE — *Schizotherium turgaicum* Borisyak, 1920; cited by Bazhanov, 1962
— *Shizotherium* sp.; cited by Bazhanov, 1962

HYRACODONTIDAE — "indricotheriid" indet.; cited by Gromova, 1959

RHINOCEROTIDAE Indet.; cited by Kostenko *et al.*, 1971

ARTIODACTYLA

ENTELODONTIDAE? Indet.; cited by Bazhanov, 1962

ANTHRACOTHERIIDAE — *Anthracotherium* sp.; cited by Bazhanov, 1962
— *Hemimeryx* sp.; cited by Bazhanov, 1962
— *Brachyodus* sp.; cited by Bazhanov, 1962

GELOCIDAE — *Lophiomeryx turgaicus*[83] Flerov, 1940; cited by Kostenko *et al.*, 1971
— *Prodremotherium* sp.; cited by Bazhanov, 1962

Lat. 44° 34′ N
Long. 67° 51′ E

Fig. 3, n° 13

U.S.S.R.
KAZAKH S.S.R.
Chimkentskaya Oblast'

Betpakdala Svita **middle Oligocene**
(= Boktykaryn Svita)
(= Kenderlyk Svita)
Locality: Kara-Tau

Bones were discovered in 1939 by Kharlov on the northeast slope of the main range of the Kara-Tau[84] Mountains near the Ak-Sumbe[85] River and 70 km NW of Suzak[86] city (see Fig. 214, p. 375). Further collecting was done by Petrushevskiy in 1940 and by Kostenko and Timush in 1955.

The continental red (predominantly clay) bed that has been known under the names of the Kenderlyk, Boktykaryn, Kyzyl Kol' and Betpakdala Svitas (according to Kostenko *et al.* 1971) is widely distributed in the piedmont of the Kara-Tau. Its sediments consist of reddish buff calcareous clay with lenses of quartz sand or (more rarely) of sandstones, silts or gravelites; near the top of the section green and variegated clays are

83 This taxon is considered *nomen nudum* by Trofimov; pers com., 1981.
84 Kara-Tau = Black Mountain.
85 Ak-Sumbe = white ramrod.
86 Suzak = water seeping between rocks on a mountain peak.

Source : MNHN, Paris

sometimes present. In the regions of the Chu and Sary-Su Rivers, where this bed is also widely exposed, its thickness varies between 40-70 m, but in the Kara-Tau piedmont thicknesses as great as 250-270 m can be found, particularly near Suzak village; near Lake Akzar it is 175 m, but in most cases the thickness is from 100-200 m. Sometimes, however, it is as little as 20-40 m. This bed unconformably overlies Eocene marine, green colored clays.

An early Oligocene age was determined by Kostenko *et al.* (1971) for this svita on the basis of ostracods and charophytes. The mammalian fauna that was collected at the Sary-Su[87] locality on the Boktykaryn River was taken by Kostenko *et al.* (1971) as representative of the same sediments at Kara-Tau. What identifiable mammals were found at Kara-Tau itself, beyond *Indricotherium* sp., was not revealed. If the fauna is the same as at Sary-Su. as is probable, we will consider it equivalent to the indricothere fauna of Chelkar-Teniz and to the fauna of Shand-Gol, that is, middle Oligocene.

Lat. 47° 17′ N
Long. 67° 7′ E

Fig. 3, n° 16

U.S.S.R.
KAZAKH S.S.R.
Dzhezkazgan Oblast'

Betpakdala Svita **middle Oligocene**
(= Botkykaryn Svita)
Locality: Kyzyl-Kak

The area known as Kyzyk-Kak[88] lies about 70 km SSW of Dzhezkazgan[89] city and consists principally of a large dry lake. The salt encrusted playa is elongated in a north-southerly direction. Along the slopes of the basin are three distinct terraces in the form of rounded steps. Exposed in these are platey, gypsiferous, reddish-brown clays, containing small iron-manganese concretions. On the lower and middle terraces, and especially in the numerous gullies that dissect the often abrupt slopes, are found rare, disassociated mammalian teeth and bones, fragments of turtles and fish vertebrae. The bone-bearing level here is a light, argillaceous sand in the upper terrace, situated between a bed of cemented gravel above and the dense, gypsiferous clays of the middle terrace below.

Geomorphologically, the region is the marginal part of the Kazakhstan fold country that is situated to the west of the Sary-Su River basin. It is characterized by plateaux, mesas or smaller remnants composed of Paleogene rocks. Several such erosional remnants exist in the area of Kyzyl-Kak and one of them is the principal fossil vertebrate locality; bones were discovered here in 1960 by the geologist Ivanushko. In 1961 the Paleontological Institute of the Academy of Sciences of U.S.S.R. sent a team that explored the northwestern part of the area and collected at the site discovered by Ivanushko, which they named Ivanushko Mound. Within this small (from 2 to 4 m in height) erosional remnant there were large quantities of the fossil remains of mammals, turtles and birds, along with isolated mammalian bones, jaws and teeth; some associated skeletal material was also found. In addition to the remains of large animals, such as hyracodontids, chalicotheres and tapiroids, numerous specimens of rodents were obtained by screen-washing of the sediment by the Paleonto-

87 Sary-Su = yellow water.

88 Kyzyl-Kak = red pond in a salty desert zone; the locality of Kykyl-Kak was formerly in Karagandinskaya Oblast', but in 1973 the Dzhezkazganskaya Oblast' was created, in which Kyzyl-Kak is now situated. References to Kyzyl-Kak Farm are the result of poor translation.

89 Dzhezkazgan = copper mine.

Source : MNHN, Paris

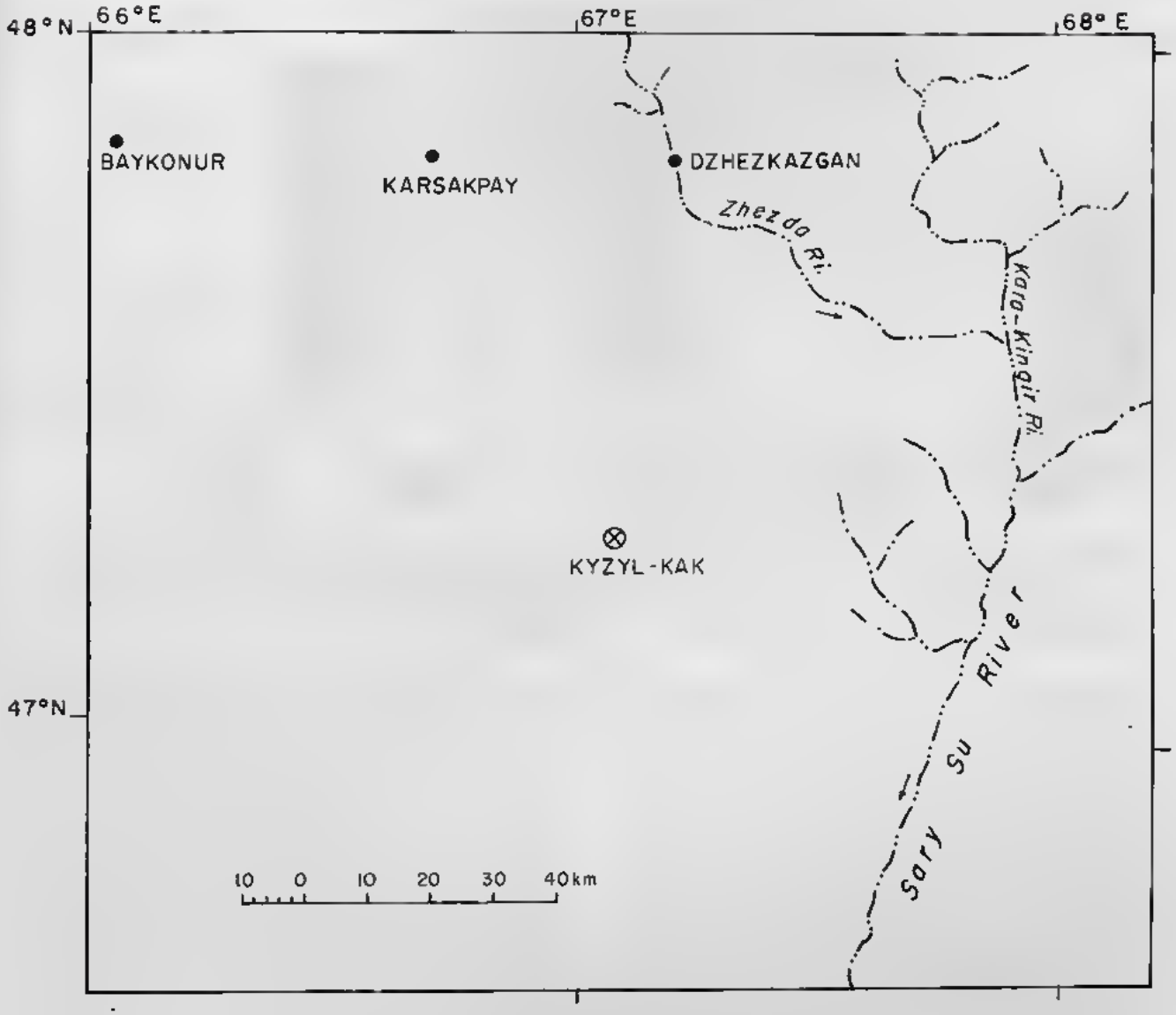


FIG. 196. — Approximate position of the locality of Kyzyl-Kak in the plain west of the Sary-Su River, Kazakh S.S.R. Modified from a map provided by G. V. Shkurkin.

logical Institute in 1961 and 1968. The Zoological Institute of the Academy of Sciences of the Kazakh S.S.R. made excavations here in the early 1970's; none have been made since.

The bone-bearing deposits consist of two levels: the upper one is exposed on the surface in the eastern part of Ivanushko Mound, while it is covered by about 1 m of sediments, mostly light brown, sandy clay, in the western part. Lithologically, the upper bone-bearing level begins with a thin (0.2 m) bed of gravel containing disassociated, small, slightly rolled and mineralized bones, and is followed by lighter brown sandy clay that contains the principal concentration of fossils. The bones in the latter level are well preserved and sometimes found associated. The upper part of this level apparently was subsequently eroded and replaced by a gravel in which are found, widely distributed, lightly rolled by transport, small bones of mammals and turtles.

About 0.50 m of strongly cemented gravel underlies the upper bone-bearing level; it contains slightly rolled, isolated bones. Below this gravel is the lower bone-bearing level. It consists of 1 m of light colored micaceous sands (of varied grain size) with stringers of clay and fine gravel. In this deposit the fossil material shows more evidence of abrasion and destruction due to transport, but rodent specimens are

Source : MNHN, Paris

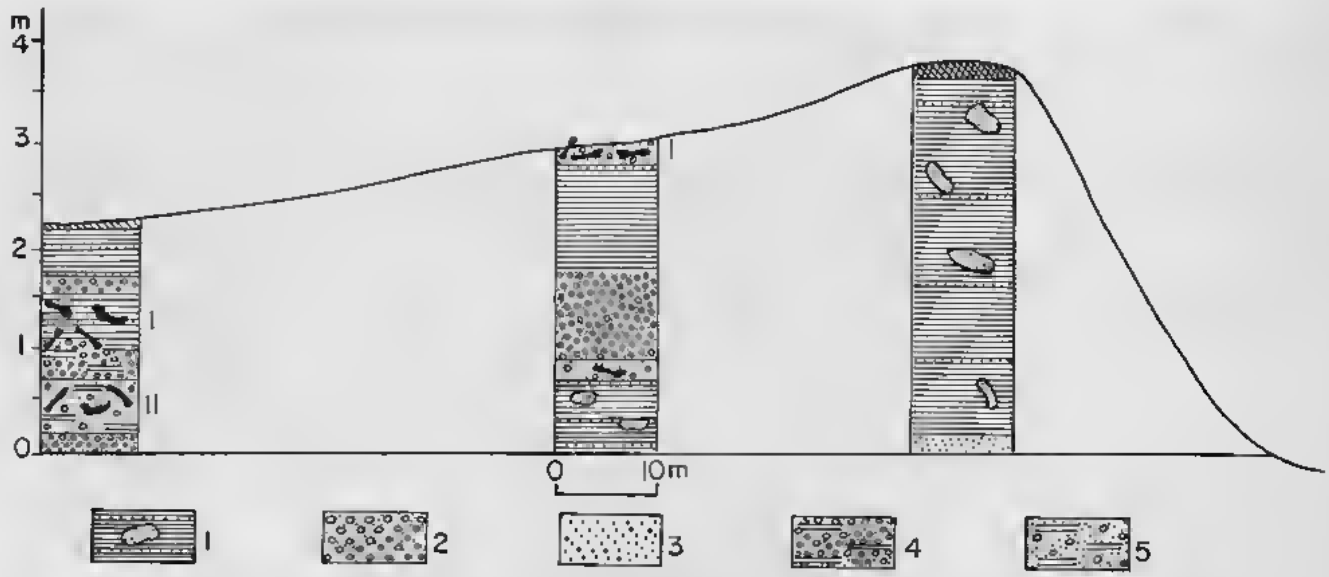


FIG. 197. Schematic section of the eastern part of Ivanushko mound, Kyzyl-Kak locality, Kazakh S.S.R. 1. sandy clay with intercalations of sand and fine gravel; 2. gravel; 3. fine sand; 4. gravel with intercalations of clay; 5. ferruginous sand with intercalations of clay and gravel. I. upper fossiliferous level. II. lower fossiliferous level. Modified from Klebanova, 1965.

known from here as well as from the other levels.

The eastern extremity of Ivanushko Mound is composed of red brown clay with lenses of micaceous sand (3.5 m) and fine sands near the bottom of the section; no vertebrate fossils were found in these deposits.

Geologically, the area of Kyzyk-Kak is sufficiently monotonous for the section in the Sary-Su valley to be taken as a reference. Along the cliffs of the Sary-Su River (and its tributaries, the Kara-Kingir and Zhezda Rivers) deposits of the Betpakdala Svita are exposed. They are red, gypsiferous clays with calcarious nodules and small iron-manganese concretions; yellowish or greenish lenses are sometimes present within the svita.

Above the clays of the Betpakdala Svita, in the Sary-Su Valley, lie the light, sandy, gravelly deposits of the Askazansor Svita. In the Kyzyl-Kak area the latter are eroded and only small patches of them remain on the surface of the plateau. All that generally remains of the Askazansor Svita is the thin layer of gravel that protects the red clays of the Betpakdala Svita. The deposits of the Askazansor Svita are correlated with the sandy clays of the late Oligocene Turgay Svita and the Chagray Svita in northern cis-Aral.

The Betpakdala Svita itself is correlated with the Chilikty Svita in the northern cis-Aral area, and with the Indricothere Svita of the Turgay Depression, well characterized by a fauna and a flora. Its age can thus be considered to be middle Oligocene, as is the latter.

Fauna of the Betpakdala Svita at Kyzyl-Kak

INSECTIVORA

ERINACEIDAE Indet.; seen by the authors

RODENTIA

CASTORIDAE — *Propalaeocastor kazachstanicus* Borisoglebskaya, 1967

APLODONTIDAE — *Prosciurus arboraptus* Shevyreva, 1971b

CRICETIDAE — *Cricetops dormitor* Matthew & Granger, 1923d; cited by Shevyreva, 1976

Source : MNHN, Paris

— *Eucricetodon asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977
(= *Cricetodon deploratus* Shevyreva, 1967)
— *Eucricetodon caducus* (Shevyreva, 1967) Lindsay, 1977
(= *Cricetodon caducus* Shevyreva, 1967)

CTENODACTYLIDAE
— *Woodomys chelkaris* Shevyreva, 1971b
— *Terrarboreus arcanus* Shevyreva, 1971b

DIPODIDAE
— *Parasminthus parvulus* Bohlin, 1946
(= *Plesiosminthus quartus* Shevyreva, 1970, *in* Green, 1977)
(= *Parasminthus quartus* (Shevyreva, 1970), *in* Engesser, 1979)

CREODONTA

HYAENODONTIDAE
— *Hyaenodon dubius* Filhol, 1873
(= *Hyaenodon aymardi* Filhol, 1882, *in* Lange-Badré, 1979); cited by Flerov *et al.*, 1974

PERISSODACTYLA

CHALICOTHERIIDAE
— *Schizotherium turgaicum* Borisyak, 1920; cited by Flerov *et al.*, 1974
(= *Kyzylkakhippus orlovi* Gabunia & Belyayeva, 1964, *in* Coombs, 1976)

HELALETIDAE
— *Colodon* sp.; cited by Flerov *et al.*, 1974

HYRACODONTIDAE
— *Indricotherium transouralicum* Pavlova 1922; cited by Klebanova, 1965
— *Ardynia* sp.
(= *Ergilia* sp., *in* Radinsky, 1967: cited by Klebanova, 1965)

ARTIODACTYLA

TRAGULIDAE Indet.; cited by Klebanova, 1965

Lat. 44′ N, approx.
Long. 78° 23′ E, approx.

Fig. 3, n° 7

U.S.S.R.
KAZAKH S.S.R.
Taldy-Kurgan Oblast'

Aktau Svita **middle and late Oligocene**

Locality: Aktau

Aktau[90] is found on the southern flank of Aktau Mountain, part of the Dzungarian Alatau Mountain Range, upslope from the right bank of the Ili River and within the Ili Depression. This is a region of extensive badlands. Reshetov (pers. com., 1981) says perhaps the only early Oligocene in Kazakhstan is found along the Ili River in the area of Aktau, but he states that no mammals have so far been discovered in this level. Bazhanov and Kostenko (1961) said there were, but this is probably due to a different conception of the term early Oligocene. Younger Oligocene beds, higher up and farther from the Ili River, do produce fossil mammals. Reshetov emphasized the very limited nature of the fossil material upon which the age determinations are based.

The fossils known from Aktau are principally due to the work of Bazhanov, who, simultaneously with geological investigation, collected

90 Aktau = white mountain.

Source : MNHN, Paris

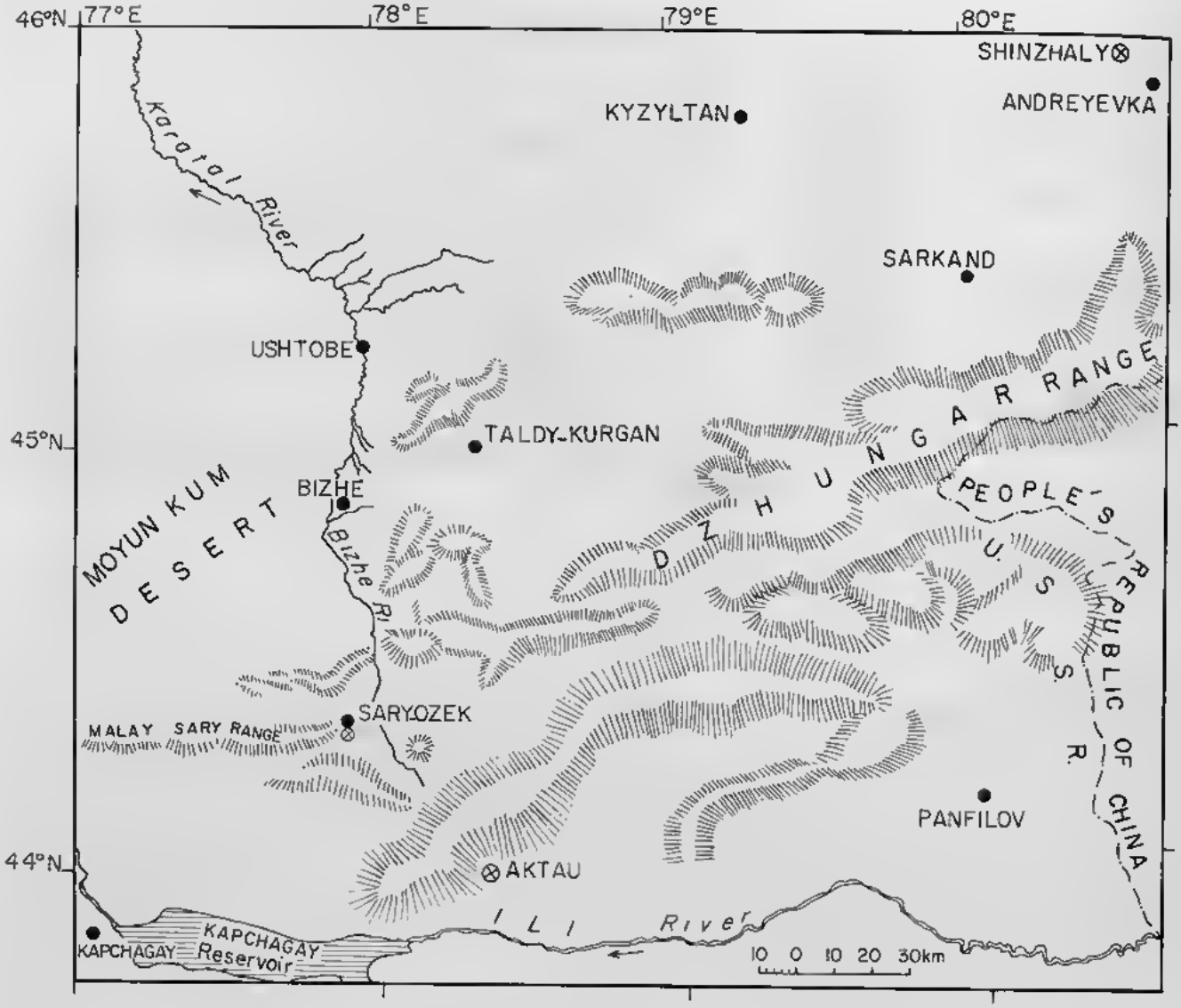


FIG. 198. — Map of the region of the Dzhungarian Alatau, Kazakh S.S.R. showing the position of the localities of Aktau, Sary-Ozek Station and Shinzhaly. Modified from maps provided by G. V. Shkurkin.

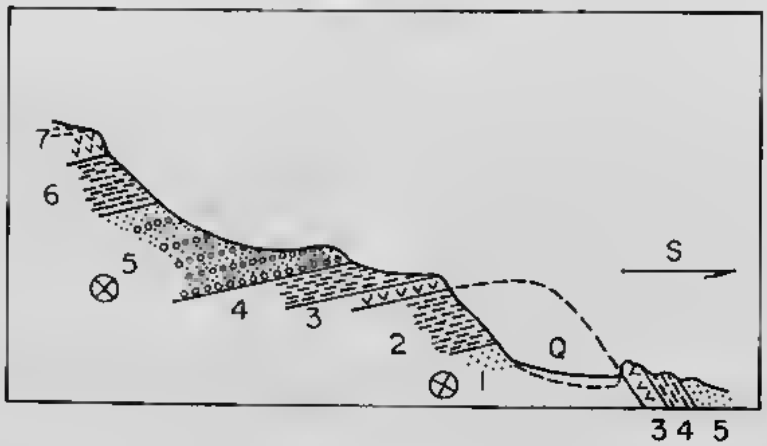


FIG. 199. — Section through part of the Aktau Mountain, Kazakh S.S.R. See text for explanation. Modified from Dmitriyeva and Nesmeyanov, 1982.

Source : MNHN, Paris

along the Ili River in the years between 1950 and 1958; Biryukov worked at the locality in 1956. A stratigraphic section was established, under the direction of Kostenko, along the 79°15′ E meridian and published by Bazhanov and Kostenko in 1961. In this section the position of all known fossils was indicated, vertebrate as well as freshwater mollusks, and the name Aktau Svita was proposed for the Oligocene fossiliferous sediments. Some uncertainty as to the exact situation of the Aktau locality has resulted; it is implied by Bazhanov and Kostenko (1961) that the collecting area was traversed by or was near the meridian of 79° 15′ E. Colleagues in Moscow (in 1981) who know the region placed it at the spot marked on the map, Fig. 198, at about longitude 78° 23′ E, which we accept here.

The succession established by Kostenko, and modified by Dmitryeva and Nesmeyanov (1982):

7.	gray green gypsiferous clays.....	160 m
6.	reddish buff clays, alternating with greenish gray silts and fine grained sandstone	50-70 m
5.	unsorted sandstone, alternating with gravelites, fines pebble conglomerates and rare clays and silts; generally yellow-ochre in color (with fossil vertebrates).....	140 m
4.	brick red, gypsiferous dense clays	25-40 m
3.	gypsum with thin but numerous lenses and stringers of greenish buff and reddish buff clays.....	20 m
2.	buff, brownish red, greenish arenaceous clays alternating with gray, buff and cherry red argillaceous sands.....	80-100 m
1.	light gray, unsorted, unconsolidated sandstone with lenses of gravelites and also reddish clays, underlain by white sands (with fossil vertebrates).....	visible for 40 m

The lower member is composed of beds 1 through 4; the latter resembles the Massaget Svita in the Fergana Depression section. Bed 1 produces vertebrate remains (especially turtle) over 1 ½ km along strike. The upper member is made up of beds 5 and 6. At the base of the bed 5 is a fine gravel that probably indicates an erosional surface. The gypsiferous clays and marls of bed 7 are considered to be analogous to the Aral' and Chul'adyr Svitas. The clays of the lower member, principally bright red in color, are characteristic of the indricothere level in the interregional stratigraphic scheme. In the upper member, the light red, banded clays are habitual for the Askazansor deposits. An unconformity separates the Aktau Svita from the underlying sediments of the Kyzybulak Svita[94], which are considered to range from Paleocene to Oligocene

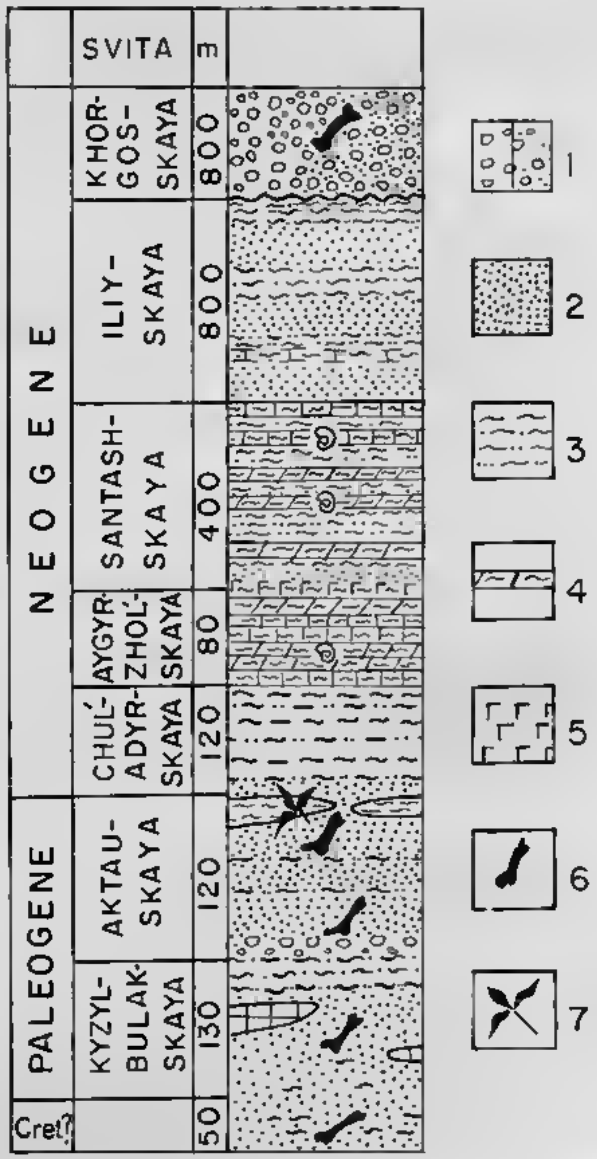


FIG. 200. Stratigraphic section in the anticline at Aktau, Kazakh S.S.R. 1. pebbles or gravels; 2. sand; 3. silt; 4. marl; 5. gypsum; 6. terrestrial vertebrate bones; 7. leaf imprints. Modified from Lavrov and Rayushkina, 1983.

94 Kyzylbulak = red spring.

Source : MNHN, Paris

in age by Lavrov and Rayushkina (1983). The overlying deposit, composed of a saliferous bed with gray green gypsiferous clays, has been dated by its many freshwater mollusks as Miocene; there is no noticeable unconformity separating the two svitas. Dmitriyeva and Nesmeyanov (1982), however, refer it to the middle Pliocene.

Although Bazhanov and Kostenko proposed the ages of early and middle Oligocene for the lower and upper fossiliferous levels, these opinions were based on a different appreciation of the correlative relationships of the vertebrate assemblages. Since *Ardynia kazachstanensis* occurs in the lower level, as well as in the large faunas of Myneske-Suyek and Chelkar-Teniz, we would tend to consider it as middle Oligocene, in accordance with the faunal sequence generally accepted today. For the upper level, the presence of *Paraceratherium* would indicate a late Oligocene or early Miocene age, while *Schizotherium* is restricted to the Oligocene; we opt therefore for the late Oligocene. Dmitriyeva and Nesmeyanov (1982) concur in these suggested ages for the two levels, but refer to the upper bed as the Askazansor Svita and to the lower one as the Indricothere Svita; Kozhamkulova (1974) uses Aktau Svita for both levels.

Fauna of the Aktau Svita (upper level, late Oligocene)

PERISSODACTYLA

CHALICOTHERIIDAE — *Schizotherium* sp.; cited by Bazhanov & Kostenko, 1961

HYRACODONTIDAE — *Paraceratherium* sp.; cited by Savinov, 1963

"RHINOCEROTIDAE" Indet., various fragments; cited by Bazhanov & Kostenko, 1961

ARTIODACTYLA

"SUIFORMES" Indet.; cited by Bazhanov & Kostenko, 1961

GELOCIDAE — *Prodremotherium flerowi* Trofimov, 1957; cited by Musakulova, 1971

Fauna of the Aktau Svita (lower level, middle Oligocene)

CREODONTA Indet.; cited by Bazhanov & Kostenko, 1961

PERISSODACTYLA

HYRACODONTIDAE — *Ardynia kazachstanensis* (Belyayeva, 1952) Radinsky, 1967 (= *Parahyracodon kazachstanensis* Belyayeva, 1952) (= *Ergilia kazachstanica* Gromova, 1960b); cited by Bazhanov & Kostenko, 1961

ARTIODACTYLA

"SUIFORMES" Indet.; cited by Bazhanov & Kostenko, 1961

Source : MNHN, Paris

Lat. 46° 55′ N, approx.
Long. 79° E, approx.

Fig. 3, n° 4

U.S.S.R.
KAZAKH S.S.R.
Taldy-Kurganskaya Oblast'

Kutanbulak Svita **middle Oligocene**

Locality: Sary-Ozek River

The locality is situated on the right bank of the Sary-Ozek River on the northeast extremity of Lake Balkhash, rather far from shore. A geologist found the only fossil remains known from there; the material was referred to *Gobiomeryx* by Musakulova (1971).

Fauna of the Kutanbulak[92] Svita at Sary-Ozek River

ARTIODACTYLA

LEPTOMERYCIDAE — *Gobiomeryx dubius* Trofimov, 1957; cited by Musakulova, 1971

U.S.S.R.
KAZAKH S.S.R.
Vostochno Kazakhstanskaya Oblast'
Zaysan Depression

Buran Svita **middle Oligocene**

Localities: Ashutas Mountain; Tayzhuzgen River (Talagay); Dzhamangora River (Podorozhnik); Karasu River (Maylibay); Kenderlyk River (Tabtym); Areal Site II, Kalmakpay River; Areal Site V, Aksyir River (Roskop); Chakpaktas River; Areal Site IX, Akkolka River

The first finds of fossil mammals in the Buran[93] Svita were made in 1958 on Ashutas Mountain by M. D. Biryukov, V. S. Erofeyev and V. V. Kuznetsov (Erofeyev, 1969). Among the most important of the new localities discovered later are those on the rivers of Tayzhuzgen, Dzhamangora, Karasu, Kenderlyk, Kalmakpay, Aksyir and Chakpaktas.

On Ashutas Mountain the Buran Svita is unconformably separated from both the overlying Oshaganda and the underlying Kusto Svitas. It is gently dipping and has a thickness of about 25 m. The fossil mammals come from rather high in the section.

At Tagalay[94], on the left bank of the Tayzhuzgen River, the Buran Svita is also unconformably situated between the Oshaganda and Kusto Svitas, but its dip is steeper and its thickness only about 10 m. Mammals were discovered at 1 and at 2.5 m from the base of the svita by Shevyreva and Chkhikvadze in the 1960's and 70's.

In the basin of the Dzhamangora River at

92 Kutanbulak = a hill with the shape of bullocks; or, stork springs.
93 Buran = twisted.
94 Talagay = razzia..

Source : MNHN, Paris

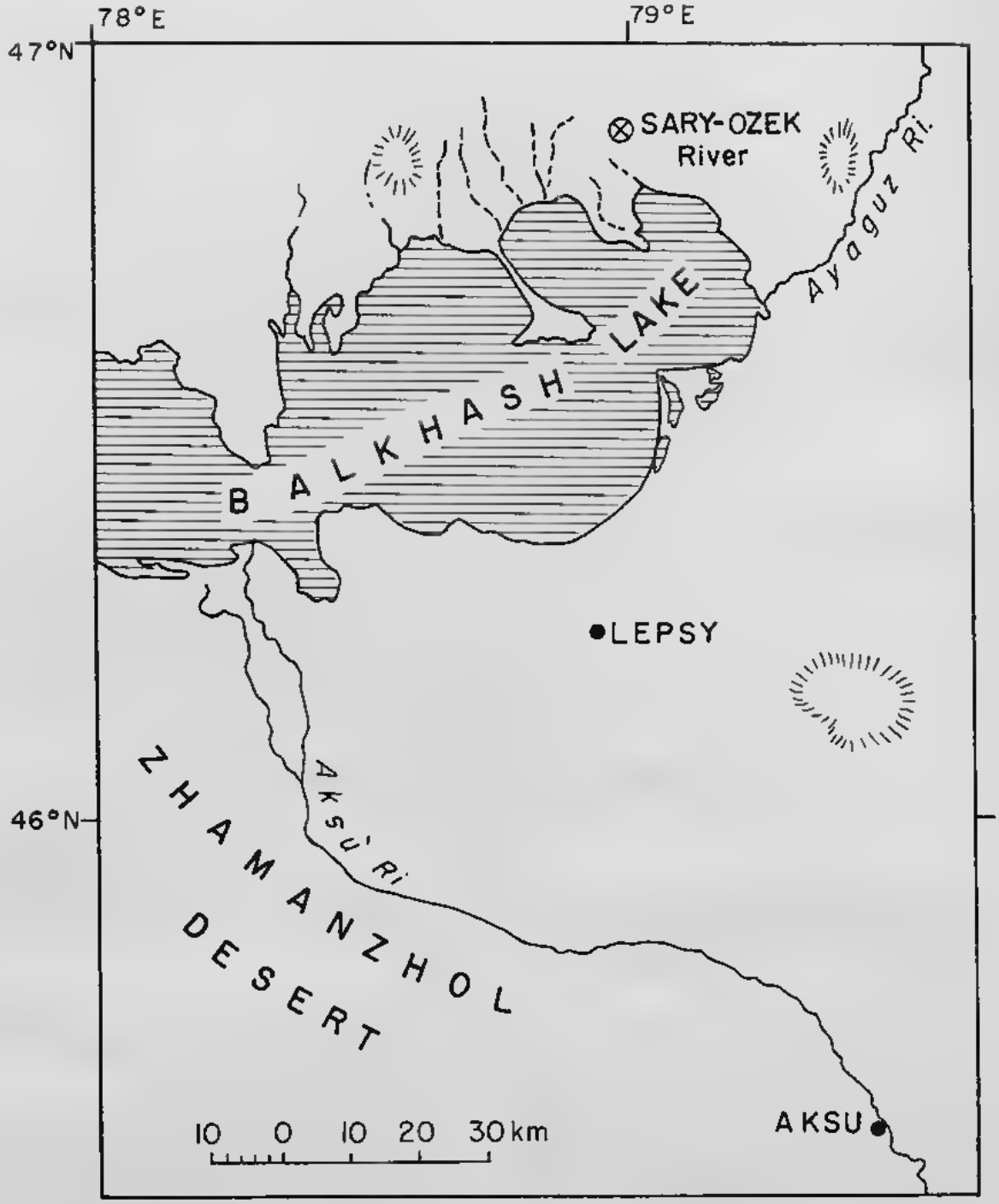


FIG. 201. — Presumed situation of the Sary-Ozek River locality at the northeastern extremity of Balkhash Lake, Kazakh S.S.R. Modified from a map provided by G. V. Shkurkin.

Source : MNHN, Paris

Podorozhnik[95] the stratigraphic situation of the Buran Svita remains the same, but with a gentle dip and a thickness of about 7 m. Fossil mammals were brought to light in the region in the 1960's by workers from the Paleontologic Institute of the Academy of Sciences of the USSR (B. A. Trofimov and others). The most important localities are situated at the base of the svita and were discovered in the 1970's by V. M. Chkhikvadze and N. S. Shevyreva.

To the west of Maylibay[96] village on the Karasu River, the svita retains its feeble dip and has a thickness of more than 10 m. It unconformably overlies the Kusto Svita and forms the surface of the outcrop. The fossil mammals known from here were found by Shevyreva and Chkhikvadze in the 1960's and 70's.

Southwest of the town of Przhevel'skoye (formerly called Kenderlyk[97], or Kendyrlik), in the valley of one of the left tributaries to the Kenderlyk River (at Tabtym)[98], the Buran Svita is separated by an erosional surface from the underlying silts and clays that probably belong to the Kusto Svita and present a thickness of more than 10 m. In a pebble bed, 2.5 m thick, at the base of the Buran Svita, fossil mammals were found by Chkhikvadze and Shevyreva in the 1960's and 70's.

On the Kalmakpay River the svita is unconformably situated between the Oshaganda and the Aksyir Svitas; it dips steeply and has a thickness of 20 m. At 5.5 m from the base of the Buran Svita (see Fig. 89, p. 165) B. A. Borisov in 1960 found fossil rhinoceros remains (Belyayeva, 1962).

Shevyreva and Chkhikvadze discovered fossil mammals at the Aksyir River Areal Site (at Raskop)[99] on the south flank of the first Aksyir anticline and at the base of the Buran Svita. The svita dips moderately here hand has a thickness of 20 m. It underlies the Oshaganda Svita unconformably and, with a similar contact, overlies a bed that is ribboned with clay and silt which apparently belongs to the Kusto Svita.

On the Chakpaktas River the Buran Svita is unconformably situated between the Oshaganda and the Aksyir Svitas (the presence of the Kusto Svita is questioned here). It has a vertical dip and a thickness of 20 - 25 m. In the lower half of the section Chkhikvadze, in the 1970's, discovered rhinoceros remains.

As with the Kusto Svita, the assignment of an age to the Buran Svita is hampered by inadequate fossil evidence. The fauna is obviously Oligocene, but it is not demonstrative of either the middle or the late part of the epoch. The Soviets attribute it to the middle Oligocene, which is provisionally followed here.

Fauna of the Buran Svita

(furnished by Dr. Shevyreva, Prof. Gabunia and Dr. Gureyev)

INSECTIVORA

Tupaiidae? Indet.; cited by Gureyev, pers. com., 1981	
Erinaceidae	— *Galerix* sp.; cited by Gureyev, pers. com., 1981
	— Galericinae indet.; cited by Gureyev, pers. com., 1981
	— *Pseudoneurogymnurus shevyrevi* Gureyev, 1979
	— *Pseudoneurogymnurus zhchikvadzei* Gureyev, 1979
	— *Amphechinus* sp.; cited by Gureyev, pers. com., 1981
Talpidae	— Uropsilinae indet.; cited by Gureyev, pers. com., 1981
	— Desmaninae? indet.; cited by Gureyev, pers. com., 1981
	— Urotrichini? indet.; cited by Gureyev, pers. com., 1981

CARNIVORA

Canidae	— aff. *Cynodictis* sp.; cited by Gabunia, pers. com., 1981

95 Podorozhnik = plaintain.
96 Maylibay = Mr. Greasy.
97 Kenderlyk = land where hemp grows.
98 Tabtym (= laplym?) I found it!
99 Roskop = excavations.

Source : MNHN, Paris

CREODONTA

HYAENODONTIDAE Indet.; cited by Gabunia, pers. com., 1981

PERISSODACTYLA

AMYNODONTIDAE — *Cadurcodon zaisanensis* Belyayeva, 1962b

ARTIODACTYLA

LEPTOMERYCIDAE — *Miomeryx* sp.; cited by Gabunia, pers. com., 1981

ORDER INDET.

DIDYMOCONIDAE Indet.; cited by Gabunia, pers. com., 1984

Source : MNHN, Paris

Lat. 21° 40′ N, approx.
Long. 94° 50′ E, approx.

BURMA

Monywa district

Pegu Formation **Oligocene to Miocene**

Locality: Myaing

For further details on the stratigraphy and history of paleontological exploration in the Tertiary deposits of Burma, consult the pages devoted to the Pondaung Sandstone.

The freshwater Pegu Formation is restricted to the more northerly parts of Upper Burma, where it overlies the Pondaung Sandstone. Bands of quartz pebble conglomerate and lateritic red beds become frequent in its northern extensions. Farther south, the Yaw Stage intercalates, as do various other beds higher in the section. It is overlain by the Irrawaddy Series. The Pegu is quite thick and undoubtedly spans a considerable amount of time. The presence of the amynodont *Cadurcodon*, immediately above the *Tritonidea* beds near Myaing would perhaps indicate a middle Oligocene age for this part of the formation. A Miocene anthracothere (*Telmatodon*) and the tragulid *Dorcatherium* have been discovered in a higher level.

Fauna of the Pegu Formation (lower part)

PERISSODACTYLA

Amynodontidae

— *Cadurcodon* sp.
(= *Cadurcotherium* sp., *in* Kretzoi, 1942; cited by Pilgrim, 1910)

MIDDLE OLIGOCENE

Composite List

(**Ak**: Aktau; **Al**: Alua; **Beg**: Beger; **Bu**: Buran; **Bui**: Buil'stiyn-Khuduk; **Bun**: Bungin-Gol; **CT**: Chelkar-Teniz; **HG**: Shand-Gol; **Ik**: Ikh-Argalantu-Nuru; **Jlt**: Jilantai Basin; **Kt**: Kara-Tau; **Kyn**: Khalyun; **Ktk**: Khatan-Khayrkhan; **Kyt**: Khaytch; **Kd**: Khotorin-Dondzhi; **KK**: Kyzyl-Kak; **MT**: Menkhen-Teg; **MgS**: Mogila-Saty; **MS**: Myneske-Suyek; **Nrn**: Narin-Bulak; **Qsy**: Qingshuiying; **Sdg**: Shuidonggou; **Shu**: Shunkt; **SS**: Sary-Su; **StJ**: Saint-Jacques; **Stz**: Shintuz-Say; **Szk**: Sary-Ozek River; **TO**: Tsagan-Obo; **Tsk**: Tsakhir; **UGg**: Ulan-Ganga; **UK**: Ulan-Khureh; **Wln**: Wulanbulage)

INSECTIVORA

Erinaceidae

HG, Tsk, Shu, Jlt, StJ — *Amphechinus rectus*
Jlt — *Amphechinus* cf. *rectus*
Nrn — *Amphechinus* cf. *minimus*
Bu — *Amphechinus* sp.
Shu, HG, Jlt — *Palaeoscaptor acridens*
TO — cf. *Palaeoscaptor acridens*
Bu — *Galerix* sp.
Bu — Galericinae indet.
Bu — *Pseudoneurogymnurus shevyrevi*
Bu — *Pseudoneurogymnurus zhchikvadzei*
HG — *Exallerix hsandagolensis*

Source : MNHN, Paris

HG — *Tupaiodon morrisi*
HG, Ktk — *Tupaiodon*? *minutus*
KK — Erinaceidae indet.

SORICIDAE

HG — *Gobisorex kingae*

TALPIDAE

Bu — Uropsilinae indet.
Bu — Urotrichini? indet.
Bu — Desmaninae? indet.
Nrn, Wln — Insectivora indet.

LAGOMORPHA

LEPORIDAE

HG, StJ — *Ordolagus teilhardi*
Jlt — *Ordolagus* sp.
Wln — Leporidae indet.

OCHOTONIDAE

HG, Bui, Tsk, Bun, Nrn, UGg, Wln — *Desmatolagus gobiensis*
HG — *Procaprolagus vetustus*
StJ — *Procaprolagus radicidens*
HG — *Procaprolagus maximus*
Jlt — *Sinolagomys major*
StJ — *Sinolagomys* cf. *major*
HG, TO — *Sinolagomys tatalgolicus*
MT — *Sinolagomys* cf. *tatalgolicus*
Jlt — cf. *Sinolagomys kansuensis*
StJ — *Bohlinotona pusillus*
Jlt — *Bohlinotona*? sp.
HG, StJ — "*Desmatolagus*" *robustus*
HG — *Agispelagus simplex*
HG, Shu — *Ochotonolagus argyropuloi*
Ik, UK, Bui, Kyt — Lagomorpha indet.

RODENTIA

TSAGANOMYIDAE

HG, Bui, TO, MT, Ik, Beg, Tsk, Shu, Bun, Kyn, Ktk, Nrn, UGg, StJ — *Tsaganomys altaicus*
Sdg, Wln — *Tsaganomys* sp.
HG, Bui, TO, MT, Ik, Tsk, Shu, Bun, Jlt, Wln, Qsy — *Cyclomylus lohensis*
Wln, Ktk — *Cyclomylus minutus*
Jlt — cf. *Cyclomylus minutus*
CT, Stz, MS — *Cyclomylus turgaicus*
Wln, Tsk — *Cyclomylus* sp.

CYLINDRODONTIDAE

HG — *Pseudocylindrodon mongolicus*
Jlt — *Ardynomys* sp.
MS — *Ardynomys*? *kazakhstanicus*
UK — Cylindrodontidae indet.

CASTORIDAE

CT — *Propalaeocastor habilis*
KK — *Propalaeocastor kazakhstanicus*
CT — *Palaeocastor* aff. *nebrascensis*
MS — *Agnotocastor aubekerovi*

Source : MNHN, Paris

APLODONTIDAE

HG, Bun, Ktk, UGg	— *Prosciurus lohiculus*
CT	— *Plesiospermophilus* sp.
HG, Nrn, KK	— *Prosciurus arboraptus*

APLODONTIDAE?

HG, Bui, TO, MT, Ik, Tsk, Shu, Ktk, Jlt	— *Selenomys mimicus*

CRICETIDAE

HG, Bui, TO, MT, Ik, Beg, Tsk, Shu, Ktk, CT, KK, Wln	— *Cricetops dormitor*
UK, SS	— *Cricetops* cf. *dormitor*
CT	— *Cricetops aeneus*
HG	— *Cricetops* cf. *aeneus*
HG, Ktk, Nrn, KK	— *Eucricetodon asiaticus*
KK	— *Eucricetodon caducus*
Kyt, Jlt	— Cricetidae indet.

TACHYORYCTOIDIDAE

HG, TO, Beg	— *Tachyoryctoides obrutschewi*
HG	— *Tachyoryctoides pachygnathus*
HG, TO	— *Tachyoryctoides tatalgolicus*

CTENODACTYLIDAE

HG, Nrn, Wln	— *Tataromys sigmodon*
Jlt	— *Tatatomys* cf. *sigmodon*
HG, Ktk, StJ	— *Tataromys plicidens*
Jlt	— *Tataromys ulantatalensis*
Jlt	— *Tataromys bohlini*
HG, StJ	— *Tataromys deflexus*
Ktk, Kyt	— *Tataromys gobiensis*
Wln	— *Tataromys* sp.
Beg	— *Tataromys*? sp.
HG, Bun, UGg, StJ, Wln	— *Karakoromys decessus*
Jlt	— *Karakoromys decessus*?
Shu	— *Karakoromys* sp.
StJ	— *Karakoromys*? sp.
Jlt	— *Leptotataromys gracilidens*
Jlt	— *Leptotataromys* cf. *gracilidens*
Jlt	— *Leptotataromys minor*
GH	— *Leptotataromys*? sp.
HG, Tsk, CT, KK	— *Woodomys chelkaris*
CT, KK	— *Terrarboreus arcanus*

DIPODIDAE

HG, Wln	— *Parasminthus tangingoli*
Jlt	— cf. *Parasminthus tangingoli*
KK	— *Parasminthus parvulus*
Wln	— *Parasminthus asiaecentralis*

CARNIVORA

MIACIDAE

HG, Ktk	— *Amphicticeps shackelfordi*
Wln	— Miacidae indet.

CANIDAE

CT	— *Cynodictis minor*
HG	— *Cynodictis*? *elegans*
HG	— *Cynodictis*? *constans*
Jlt, Bu	— *Cynodictis*? sp.
HG, Ktk	— *Amphicynodon teilhardi*

Source : MNHN, Paris

FELIDAE

HG — cf. *Nimravus* sp.
HG — cf. *Proailurus* sp.

AMPHICYONIDAE

StJ — *Amphicyon*? sp.

MUSTELIDAE

HG — cf. *Plesictis* sp.
HG, Shu, Jlt — *Palaeogale ulysses*
TO — *Palaeogale* cf. *ulysses*

VIVERRIDAE

HG — *Palaeoprionodon gracilis*
Jlt, SS, Wln Carnivora indet.

CREODONTA

HYAENODONTIDAE

HG — *Hyaenodon pervagus*
HG, CT, MS, KK — *Hyaenodon dubius*
HG — *Hyaenodon filholi*
Shu — *Hyaenodon chunkhtensis*
HG, Shu, StJ, SS — *Hyaenodon* sp.
Jlt, Wln — *Hyaenodon*? sp.
Bu — Hyaenodontidae indet.
Ak Creodonta indet.

PERISSODACTYLA

CHALICOTHERIIDAE

CT, MS, SS, KK — *Schizotherium turgaicum*
StJ — *Schizotherium* cf. *avitum*
CT — *Schizotherium chucuae*
SS, Wln, Qsy — *Schizotherium* sp.

HELALETIDAE

CT, MS — *Colodon orientalis*
KK — *Colodon* sp.
StJ — "*Hyrachyus*" sp.

HYRACODONTIDAE

Stz, MS — *Indricotherium brevicervicale*
HG, Ttl, MgS, CT, Stz, Al, MS, KK, StJ, Sdg, Qsy — *Indricotherium transouralicum*
Shu, Kt — *Indricotherium* sp.
CT, Stz, MS, Ak — *Ardynia kazachstanensis*
KK — *Ardynia* sp.
CT — *Triplopus*? *turgaiensis*
Wln, StJ — *Paraceratherium* sp.
Wln — *Aprotodon* sp.
SS, Sdg, Wln — Hyracodontidae indet.

RHINOCEROTIDAE

HG, UGg — *Eggysodon minor*
CT, MS — *Eggysodon turgaicus*
Jlt — *Aceratherium* sp.
StJ — *Aceratherium*? sp.
SS — Rhinocerotidae indet.

AMYNODONTIDAE

MS — *Cadurcodon kazakademius*
Bu — *Cadurcodon zaisanensis*
Wln — *Cadurcodon ardynensis*
Jlt — *Cadurcodon* sp.

Source : MNHN, Paris

CT — *Cadurcodon*? sp.
Kd — Amynodontidae indet.

ARTIODACTYLA

ENTELODONTIDAE

CT — *Entelodon diconodon*
MS — *Entelodon major*
Qsy — *Entelodon ordosius*
Tsk — *Entelodon* sp.
Mgs — Entelodontidae indet.
SS — Entelodontidae? indet.

ANTHRACOTHERIIDAE

CT — *Hemimeryx turgaicus*
SS — *Hemimeryx* sp.
CT, SS — *Brachyodus* sp.
CT — *Hyoboops* sp.
SS — *Anthracotherium* sp.

LEPTOMERYCIDAE

Tsk, Bu — *Miomeryx* sp.
HG — cf. *Miomeryx* sp.
Szk — *Gobiomeryx dubius*

CERVIDAE

HG, TO, MT, Jlt — *Eumeryx culminus*
StJ — *Eumeryx* cf. *culminus*
TO, Wln, Sdg — *Eumeryx* sp.
Qsy — "*Eumeryx*" sp.
StJ — Cervidae indet.

SUIDAE

CT — *Propalaeochoerus* sp.

GELOCIDAE

HG, Tsk — *Pseudomeryx gobiensis*
HG — *Pseudomeryx hypertalonidus*
CT — *Prodremotherium flerowi*
SS — *Prodremotherium* sp.
CT, SS — *Lophiomeryx turgaicus*
Wln — *Lophiomeryx gobiae*
Wln — *Lophiomeryx* sp.
Wln — Bovidae? indet.
TO, MS, KK, Wln — Tragulidae indet.

RUMINANTIA indet.

HG — *Palaeohypsodontus asiaticus*
Jlt — *Palaeohypsodontus* cf. *asiaticus*
Jlt — *Hanhaicerus qii*
Bui, Bun, UGg, Wln, UK Artiodactyla indet.

ORDER Indet.

DIDYMOCONIDAE

HG, Shu, CT — *Didymoconus colgatei*
HG — *Didymoconus berkeyi*
Ktk — *Didymoconus berkeyi*?
Jlt — cf. *Didymoconus berkeyi*
Jlt — *Didymoconus* sp.
Bu — Didymoconidae indet.

Source : MNHN, Paris

Lat. 39° 30′ N, approx.
Long. 94° 35′ E, approx.

Fig. 2, n° 26

CHINA
GANSU PROVINCE
(Kansu)
Aksay Kazakzu Autonomous County
Taben Buluk Area

Sediments of Taben Buluk **late Oligocene**

Localities: Taben Buluk and Yindirte

Early Tertiary fossils, among specimens and data pertaining to many other disciplines, were obtained in western Gansu by Birger Bohlin, member of Sven Hedin's Sino-Swedish Expedition to the Northwestern Provinces of China. Since then (the early 1930's) there has been no further paleontological exploration in the area nor exploitation of the localities found by Bohlin.

Taben Buluk[1] is a group of springs at the

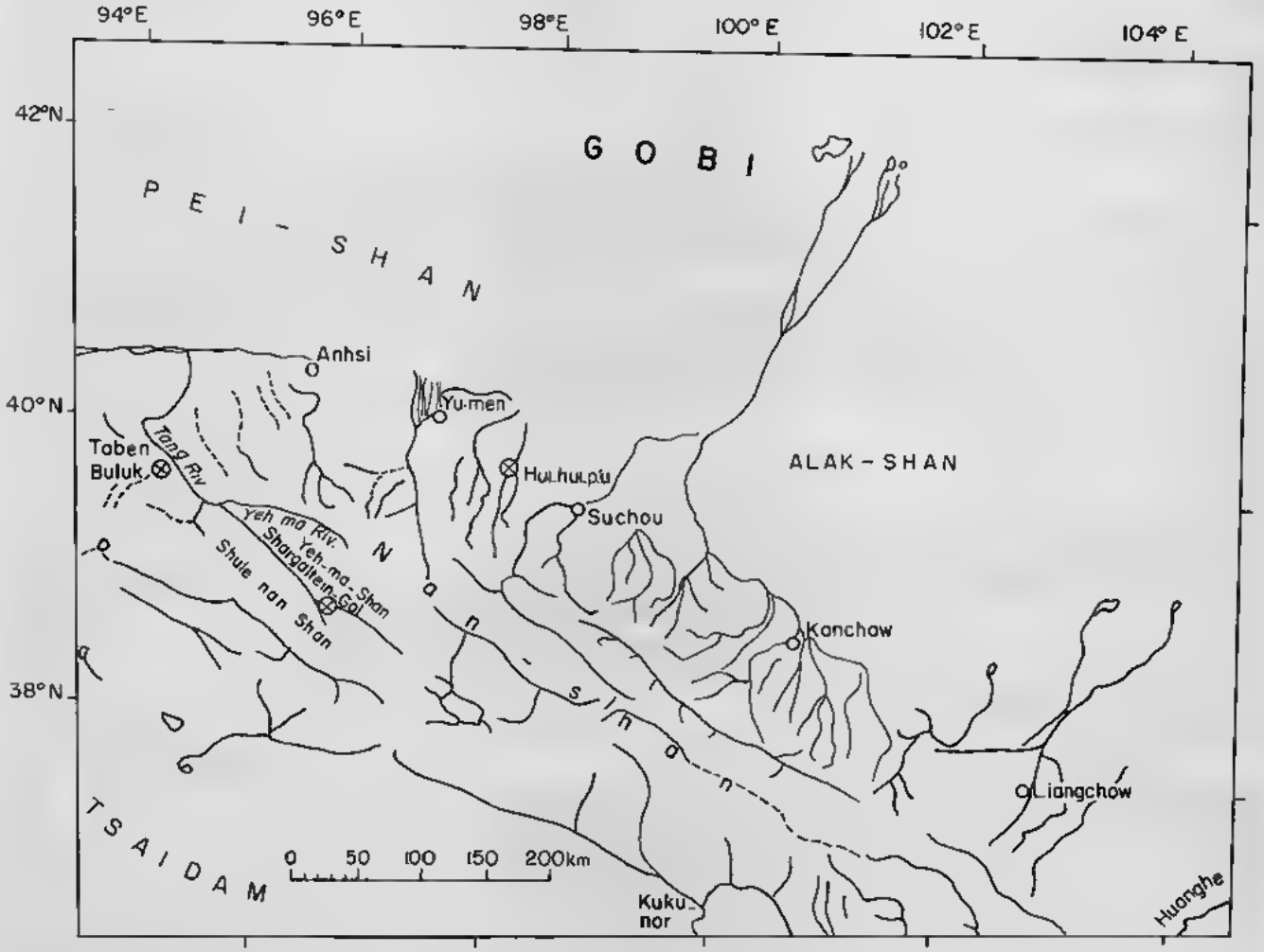


FIG. 202. — Sketch map showing the geographical relationships of Bohlin's principal collecting areas in western Gansu. Modified from Bohlin, 1945.

1 Taben Buluk = 5 springs.

Source : MNHN, Paris

northern foot of the Anem Barin Ula on the great caravan road between Tunhuang and Sirtun that has given its name to the fossiliferous area (comprising the general name of Taben Buluk and the locality of Yindirte[2] worked by Bohlin. The badlands investigated during his three months stay in 1931 and 1932 extend for about 20 km chiefly towards the east, between Taben Buluk and the mouth of the Tang-ho (Tangin gol). These badlands form a belt about 7 km wide and possess a very complicated structural geology; their sediments are intensively folded and cut by a series of great faults.

The Yindirte locality is situated 5 km east of Taben Buluk and yielded the best of the collections; furthermore, the material was found in place.

The fossils were collected in three beds belonging to a series (oriented vertically at Yindirte) that measured about 40 m in total thickness. The fossiliferous sediment consists of brick red clay, either pure or with grains of sand to small pebbles; it is rich in remains of small rodents and insectivores; in the clays the fossils are less abundant but more complete. Larger animals are rare and mostly represented by indeterminate fragments. The collection from Yindirte was amassed during about 24 man-days of work and retains a great potential.

Still farther east, in the area of Tieh-chiang-ku, a mandible of *Schizotherium* was found (see Coombs, 1978, for comments) along with specimens of "*Sayimys*". They apparently indicate a fauna younger than that from Yindirte; Bohlin regards the beds containing "*Sayimys*" as being of Miocene age, but it is not clear whether all the Tieh-chiang-ku sediments are the same age.

The Taben Buluk badlands are made up of three principal units which become increasingly coarse upwards. At the bottom of the sequence is found a level typified by brick red argillaceous and sandy silt, sandstone and, rarely, fine conglomerate. Above this is purplish red argillaceous and sandy silt, sandstone and moderately coarse conglomerate; the latter forms a broad belt in the center of the western part of the badlands and, where the conglomerate alternates with clay mixed with small stones, has produced

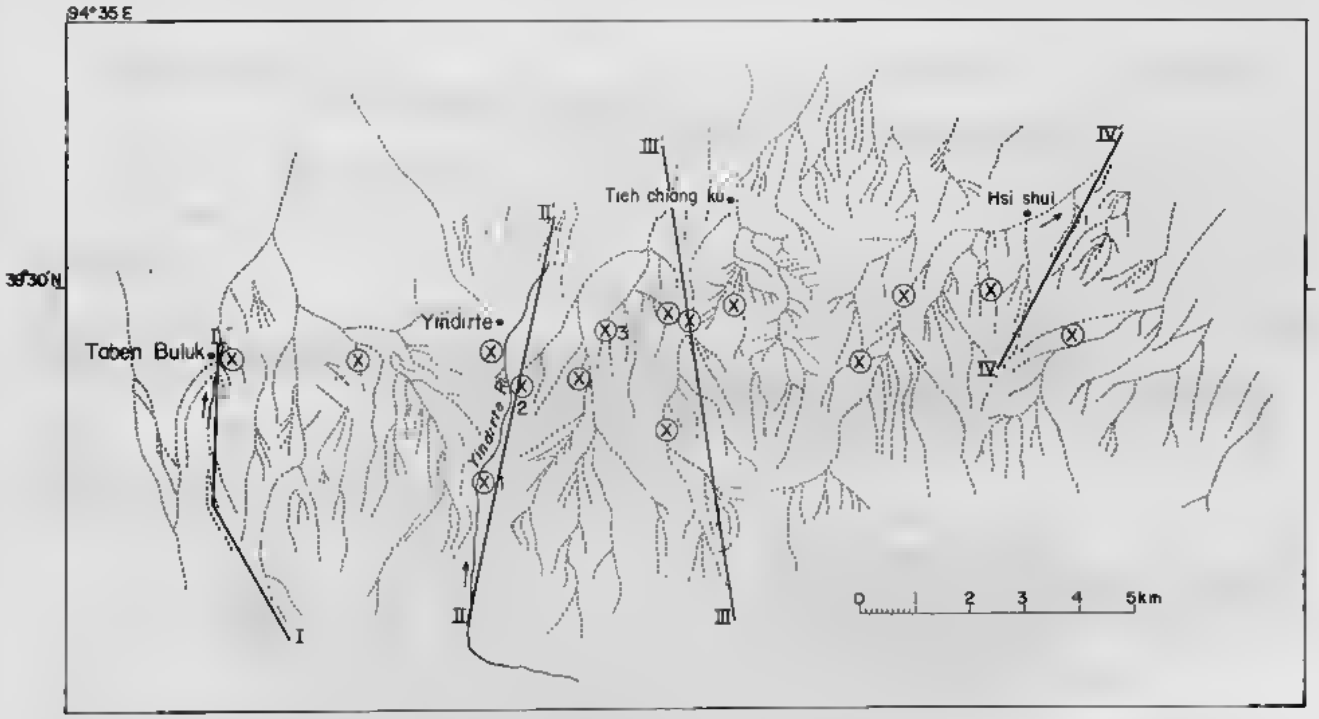


FIG. 203. — Map of the Taben Buluk badlands, Gansu. Bohlin in 1946 noted that the locality in the upper Yindirte valley should be situated closer to the foot of the mountain than it is on this map. Localities numbered 1, 2 and 3 are the major fossil producing sites. Modified from Bohlin, 1942 and 1960.

2 Yindirte = terrace.

Source : MNHN, Paris

most of the vertebrate fossils. On top are coarse conglomerates in thick beds that alternate with equally thick layers of sandstone. This section is limited horizontally in extent as it is presumed to represent old alluvial cones, and is also isolated by faults from the surrounding rocks.

The fossils of the Taben Buluk area (*sensu stricto*) could not, or rarely, be attributed with precision to a given stratigraphic level. In contrast, it was possible to collect at Yindirte from three different levels. These were termed the northern bed (the richest), the middle bed, and the southern bed (the poorest).

Much of the evidence for the relative age of Bohlin's localities was derived from study of the lagomorphs. *Sinolagomys major* occurs in both the northern and the middle bed; furthermore, the northern bed produced *Sinolagomys kansuensis* and *Desmatolagus* sp. (*shargaltensis*?). In the Shargaltein valley, *Desmatolagus shargaltensis* and *D. parvidens* occur at Shih-chiang-tzu-ku along with *Sinolagomys major, S. kansuensis* and *S. gracilis*. At Wu-tao-ya-yu only *Desmatolagus* was found.

Bohlin assumed, after a detailed analysis, that his Gansu faunas represented a succession in which differences of age were slight. He regarded the Shand-Gol assemblage as older than the

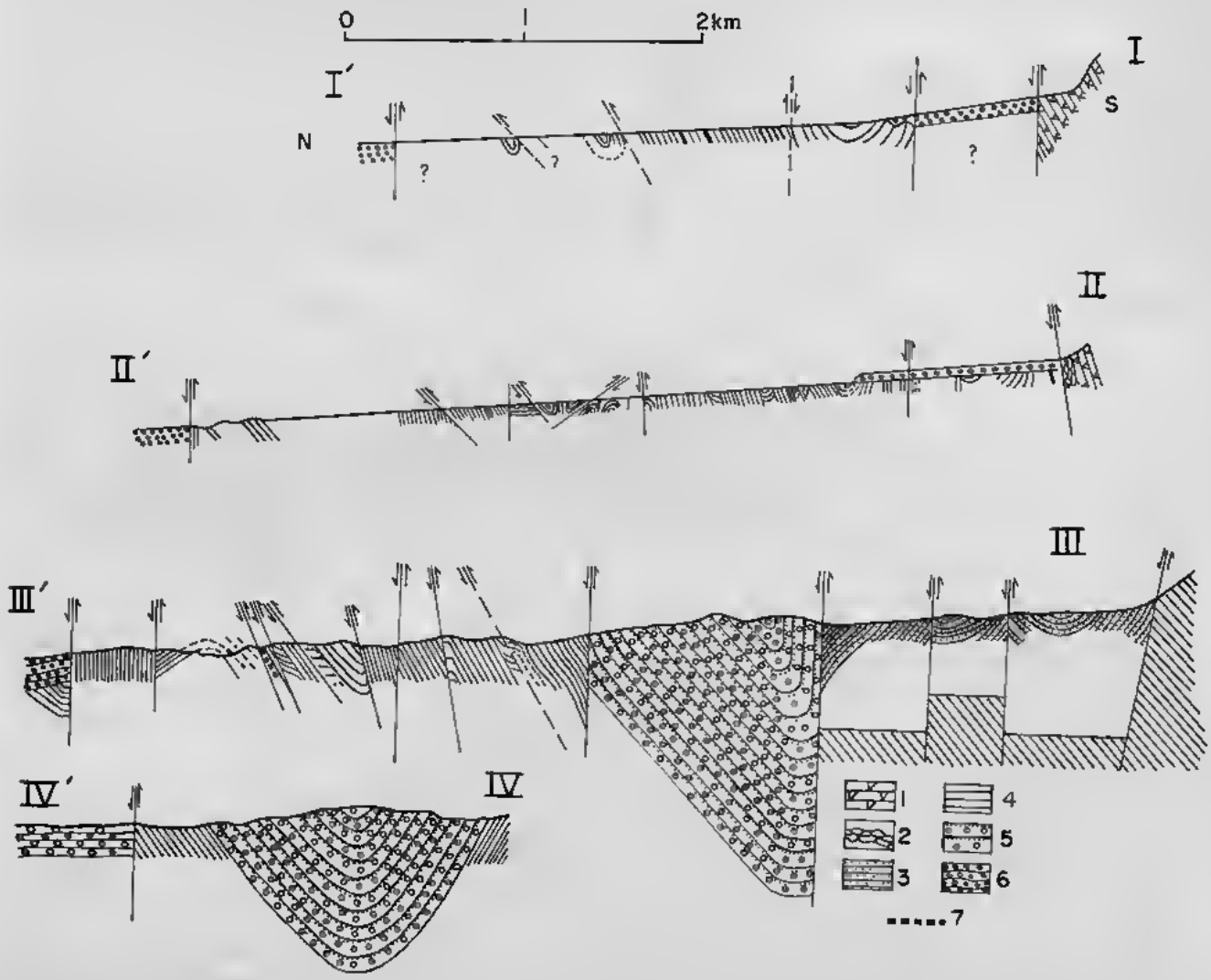


FIG. 204. — Cross sections taken through the Taben Buluk badlands, Gansu. 1. old rocks (limestone, etc.); 2. fault breccia; 3. fine brick red sediments; 4. purple fine conglomerate, sandstone and silt; 5. coarse conglomerate; 6. young conglomerate. The mammalian fossils were found in both the fine brick red sediments (3) and the purple fine conglomerate, sandstone and silt (4). All sections are to the same scale. Modified from Bohlin, 1960.

Source : MNHN, Paris

oldest of his faunas and that of Saint-Jacques appeared to him to be situated between Shand-Gol and the Taben Buluk (Yindirte) localities.

An early Miocene fauna from the Xiejia Formation, Xining Basin (Qinghai Province) has an important bearing on the correlation of Taben Buluk. The Xiejia fauna was found by an IVPP team in 1978 and described by Li and Qiu in 1980 and Li, Qiu & Wang (1981). Although most of the elements of the Xiejia fauna are endemic, some, like *Eucricetodon, Parasminthus, Brachypotherium* and *Oioceros*, indicate intercontinental exchange and an Aquitanian-Burdigalian age. Closest correlation of this fauna is with the Taben Buluk assemblage of Gansu, whereby most of the genera are surviving forms continued from the Taben Buluk fauna. The species from Xiejia, however, are more advanced in morphological characters. This similarity favors considering Taben Buluk and Yindirte as late Oligocene in age.

Fauna of Yindirte in the Taben Buluk area

INSECTIVORA

ERINACEIDAE
- — *Amphechinus* cf. *rectus* (Matthew & Granger, 1924b); cited by Bohlin, 1942
  (= *Palaeoerinaceus rectus* (Matthew & Granger, 1924b) Bohlin, 1942)
  (= *Palaeoscaptor rectus* Matthew & Granger, 1924b)
  (= *Amphechinus? rectus* (Matthew & Granger, 1924b) Butler, 1948)
- — *Amphechinus minimus* (Bohlin, 1942) Butler, 1984
  (= *Palaeoerinaceus minimus* Bohlin, 1942)
  (= *Parvericius montanus* Kœrner, 1940, *in* Rich & Rasmussen, 1973)
  (= *Palaeoerinaceus kansuensis* Bohlin, 1942, *in* Rich & Rasmussen, 1973)
- — Erinaceidae? indet.; cited by Bohlin, 1946

SORICIDAE Indet.; cited by Bohlin, 1942

TALPIDAE? Indet.; cited by Bohlin, 1942

PRIMATES

FAMILY Indet.
- — *Kansupithecus* Bohlin, 1946 (lower molar)

LAGOMORPHA

OCHOTONIDAE
- — *Desmatolagus* sp.; cited by Bohlin, 1942
- — *Sinolagomys kansuensis* Bohlin, 1937
- — *Sinolagomys major* Bohlin, 1937

RODENTIA

SCIURIDAE?
- — "*Sciurus*" sp.; cited by Bohlin, 1946

CRICETIDAE
- — *Eucricetodon* sp.; cited by Lindsay, 1977

TACHYORYCTOIDIDAE
- — *Tachyoryctoides* sp.; cited by Boblin, 1946
- — *Tachyoryctoides* cf. *obrutschewi* Bohlin, 1937; cited by Bohlin, 1946
- — Tachyoryctoididae indet.
  (= Rhizomyidae? indet.; cited by Boblin, 1946)

CTENODACTYLIDAE
- — *Tataromys grangeri* Bohlin, 1946
- — *Tataromys sigmodon* Matthew & Granger, 1923d; cited by Bohlin, 1946
- — *Tataromys* cf. *plicidens* Matthew & Granger, 1923d; cited by Bohlin, 1946
- — *Yindirtemys woodi* Bohlin, 1946

Source : MNHN, Paris

DIPODIDAE
— *Parasminthus asiaecentralis* Bohlin, 1936[3]
— *Parasminthus tangingoli* Bohlin, 1946
— *Parasminthus parvulus* Bohlin, 1946
— Sicistinae? indet.; cited by Bohlin, 1946

CARNIVORA Indet.; cited by Bohlin, 1946

PERISSODACTYLA

CHALICOTHERIIDAE — *Schizotherium*? sp.; cited by Bohlin, 1946

HYRACODONTIDAE — *Aceratherium* sp.; cited by Conroy & Bown, 1974 (= *Indricotherium* sp.: cited by Hu, 1962, V.P. (2))

RHINOCEROTIDAE Indet.; cited by Bohlin, 1946

ARTIODACTYLA

CERVIDAE — *Eumeryx* sp.; cited by Bohlin, 1946

ORDER Indet.

DIDYMOCONIDAE
— *Didymoconus* sp.; cited by Bohlin, 1946
— aff. *Didymoconus*?; cited by Bohlin, 1946

Note: Bohlin included in bis faunal list a number of forms he cited farther in the same text as being of Miocene age: *Sayimys obliquidens* Bohlin, 1946[4], *Bunolophodon*? ("*Trilophodon*") *connexus* (Hopwod, 1935), *Schizotherium* sp., a larger mastodon, a cervulinae, a bovid, a small rhinocerotid, a large rhinocerotid, and *Kansupithecus* (symphysis). Conroy & Bown, 1974, also commented on these Miocene forms.

This material was found at the localities of Tieh-chiang-ku and Hsi-shui, in the eastern part of the Taben Buluk badlands.

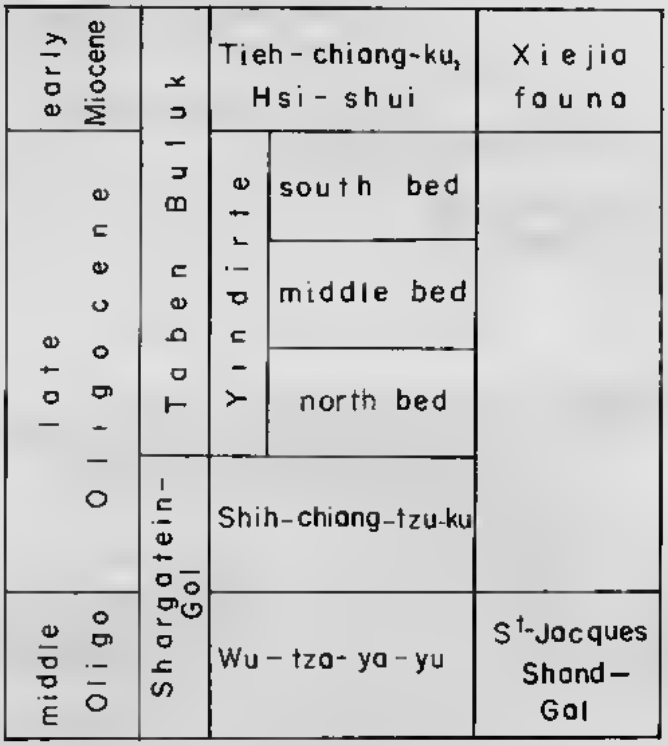


FIG. 205. — Stratigraphic sequence of the fossiliferous sites in western Gansu found and exploited by Bohlin. Deduced from Bohlin, 1942, 1946 and 1960.

3 The synonymy of this genus with *Plesiosminthus*, proposed by Stehlin & Schaub, 1951, and followed by Kowalski, 1974, is rejected by Engesser, 1979 and Hugueney & Vianey-Liaud, 1980. The species name was originally hyphenated, a practice that is not recognized by the International Code of Zoological Nomenclature.

4 = *Metasayimus obliquidens* (Bohlin, 1946), *in* Jaeger, 1971; denied by Wood, 1977.

Source : MNHN, Paris

Lat. 38° 45′ N, approx.
Long. 96° 18′ E, approx.

CHINA
Gansu Province
(Kansu)

unnamed formation **late Oligocene**

Shargaltein Gol Area

The Shargaltein Gol[5] flows between the Yeh ma shan (mountains) to the north and the Shule nan shan (Humbolt Range) to the south for about 10 km in a rather narrow valley before widening into a plain approximately 6 km wide and continuing to the east for at least 20 km. Still farther east, in a small basin situated in the ever-widening plain, a collection of fossils was obtained by Bohlin in 1932 during two stays. These were described in 1937, 1942 and 1946 and completely revised in the latter work. The area is about 120 km east of Taben Buluk.

The fossiliferous rocks are exposed in a strongly dissected belt along the southern border of the basin. Faults delimit this basin, which is furthermore cut by at least two other major faults. The sediments show less variation than in the Taben Buluk area. Most of them are brick red, but light brown conglomerates and conglomerates of an impure red color are also present.

The fossils collected from the Shargaltein badlands were picked up from the surface, which allows the possibility that a mixture from more than one level was made. Two areas lying about 19 km apart constitute the collecting sites: these are called Shih-chiang-tzu-ku and Wu-tao-ya-yu.

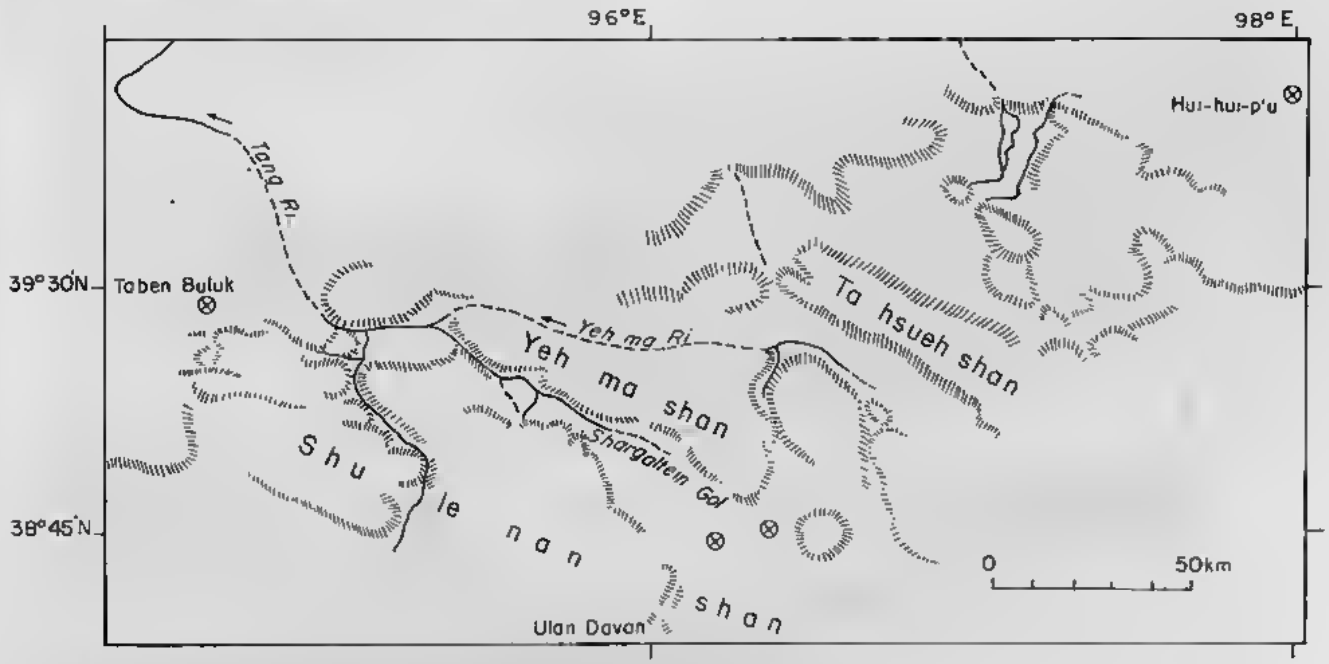


FIG. 206. — General map of the region in western Gansu where B. Bohlin in the 1930's made his discoveries of Tertiary mammalin fossils. Modified from Bohlin, 1945.

5 Shargaltein Gol (the upper part of the Dang he (= Tang-Ho, = Tong he) or Dun huang (= Tun huang) River) = auburn colored stream; Tang-Ho (= Tangin Gol) = stream with sand banks.

Source : MNHN, Paris

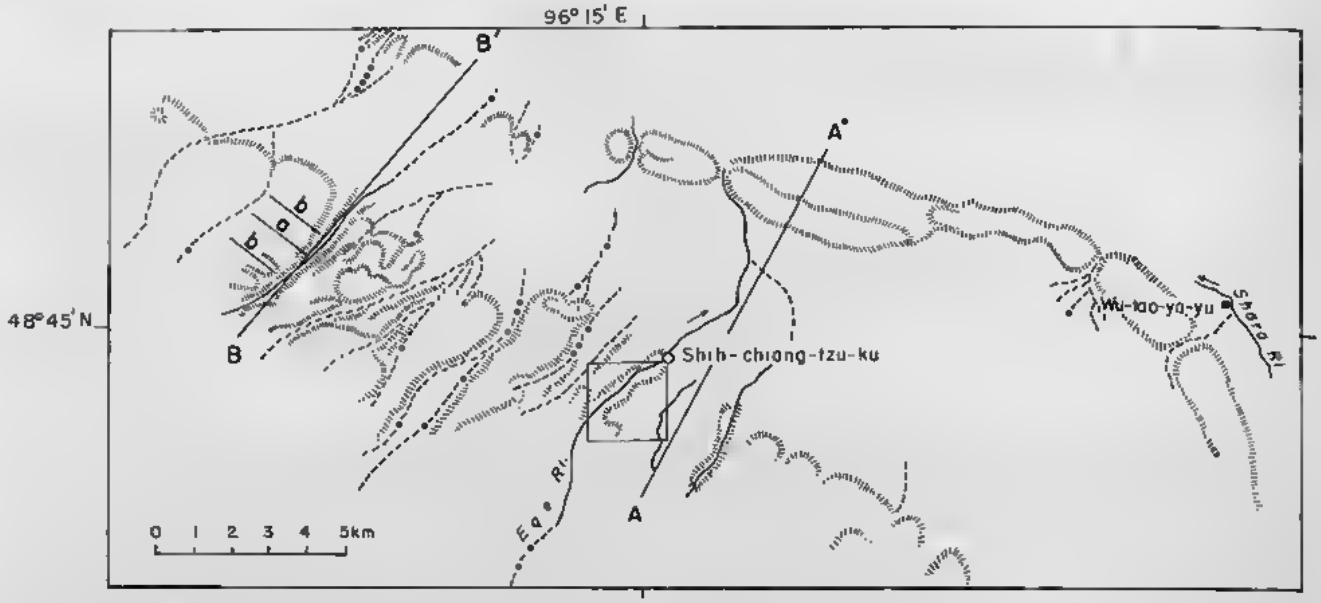


FIG. 207. — Sketch map of the Shih-chiang-tzu-ku area in the Shargaltein Gol valley, Gansu. Most of the fossils from the Shargaltein valley were collected in the square south of Shih-chiang-tzu-ku (2 km²). A small collection was made from the ridge south of Wu-ta-ya-yu. Modified from Bohlin, 1960..

The former is located on the north slope of the Shule nan Shan, near Ulan Davan[6], on the south bank of the Eqe he[7]; the latter locality, 10 km to the north east, is on the left bank of the Shara River. By the absence of *Sinolagomys* at Wu-tao-ya-yu an early stage in the faunal development is suggested. Moreover, the material from Shih-chiang-tzu-ku may be mixed. Bohlin proposed that a succession of faunas, differing only slightly in age, were present in this region of his field research; that from Wu-tao-ya-yu would be the oldest, Yindirte (Taben Buluk) the youngest, and Shih-chiang-tzu-ku would be intermediate. In suggesting a correlation of the Shargaltein Gol faunas, Bohlin (1946, p. 247) equated Wu-tao-ya-yu possibly with Saint-Jacques (both being considered as younger than the Shand-Gol assemblage). In large part this opinion was based on his analysis of the lagomorphs studied.

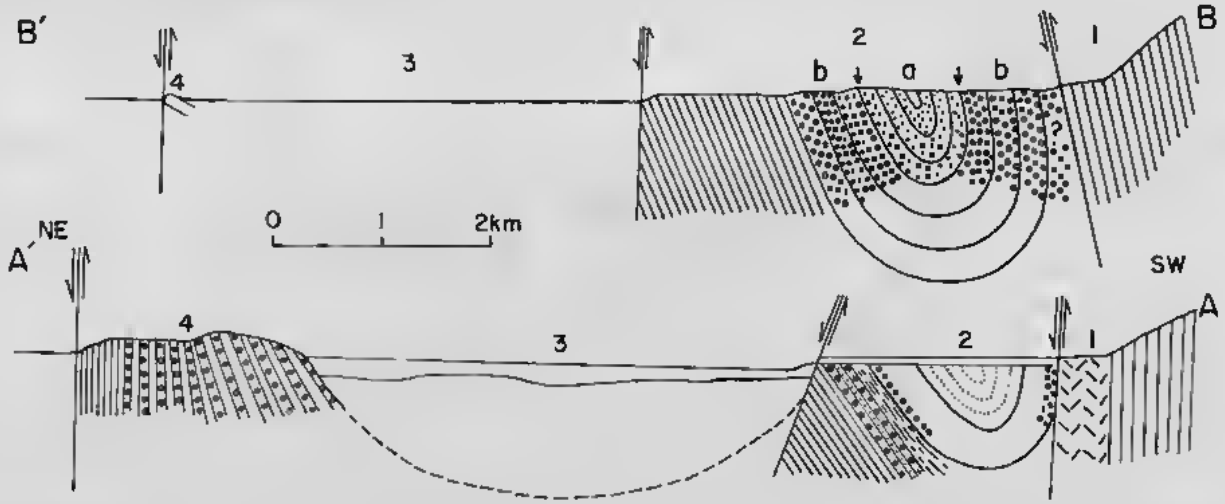


FIG. 208. — Cross section in the area of the Shargaltein Gol valley, Gansu, where fossil mammals were found. 1. old rocks; 2. and 4, Oligocene conglomerate, sandstone and silt; 3. alluvial plain. The collection at Shih-chiang-tzu-ku was made in the beds marked b, a, b of division 2; those from Wu-tao-ya-yu came from division 4 and are presumably older. Modified from Bohlin, 1960.

6 Ulan Davan = red pass.
7 Eqe he (= Yu-ke).

Source : MNHN, Paris

Fauna of the Shargaltein Gol

(* = found at Wu-tao-ya-yu; with the possible exception of the carnivore they are all also found at Shih-chiang-tzu-ku)

INSECTIVORA

ERINACEIDAE
— *Palaeoscaptor* cf. *acridens* Matthew & Granger, 1924b
(= *Palaeoerinaceus* cf. *acridens* (Matthew & Granger, 192b); cited by Bohlin, 1946
— *Amphechinus* sp.
(= *Palaeoscaptor*? sp.; cited by Bohlin, 1937)
(= *Palaeoerinaceus*? sp.; cited by Bohlin, 1946)
(= *Amphechinus* = *Palaeoscaptor* = *Palaeoerinaceus in* Butler, 1948)
— Erinaceidae indet.; cited by Bohlin, 1946
(= Insectivore?; cited by Bohlin, 1937)

LAGOMORPHA

OCHOTONIDAE
— *Desmatolagus shargaltensis* Bohlin, 1937
— *Desmatolagus parvidens* Bohlin, 1937, *in* de Muizon, 1977
(= *Desmatolagus*? *parvidens* Bohlin, 1937)
*— *Desmatolagus* sp.; cited by Bohlin, 1937
— *Sinolagomys kansuensis* Bohlin, 1937
— *Sinolagomys major* Bohlin, 1937
— *Sinolagomys gracilis* Bohlin, 1942
(= *Sinolagomys minor* Bohlin, 1937, *in* Bohlin, 1942)

RODENTIA

SCIURIDAE Indet.; cited by Bohlin, 1946

TSAGANOMYIDAE
*— *Tsaganomys altaicus* Matthew & Granger, 1923c; cited by Bolhin, 1937

TACHYORYCTOIDIDAE
— *Tachyoryctoides obrutschewi* Bohlin, 1937
— *Tachyoryctoides intermedius* Bohlin, 1937
— *Tachyoryctoides pachygnathus* Bohlin, 1937

CTENODACTYLIDAE
— *Tataromys* cf. *plicidens* Matthew & Granger, 1923d; cited by Bohlin, 1937
*— cf. *Tataromys* sp.; cited by Bohlin, 1946
— *Karakoromys* cf. *decessus* Matthew & Granger, 1923d; cited by Bohlin, 1937
*— cf. *Karakoromys* sp.; cited by Bohlin, 1946
— *Leptotataromys gracilidens* Bohlin, 1946

DIPODIDAE
— Sicistinae indet.; cited by Bohlin, 1946

*CARNIVORA Indet.; cited by Bohlin, 1946

PERISSODACTYLA

HYRACODONTIDAE
*— *Indricotherium* sp.; cited by Bohlin, 1946

ARTIODACTYLA

CERVIDAE
*— *Eumeryx*? sp.; cited by Bohlin, 1946
— Cervulinae? indet.; cited by Bohlin, 1946

BOVIDAE Indet.; cited by Bohlin, 1946

*ARTIODACTYLA Indet.; cited by Bohlin, 1946

ORDER Indet.

DIDYMOCONIDAE
— *Didymoconus* sp.; cited by Bohlin, 1946

Source : MNHN, Paris

Lat. 40° N, approx.
Long. 98° E, approx.

Fig. 2, n° 27

CHINA
GANSU PROVINCE
Hui-hui-p'u area

unnamed formation **Oligocene**
Locality: Shih-ehr-ma-ch'eng

Birger Bohlin found fossil mammals at Shih-ehr-ma-ch'eng first in 1930. On two other occasions, both in 1931, he collected there over a period that totaled about 2 week's time. During his third and last stay he also prospected in the region and collected vertebrates of the Shih-ehr-ma-ch'eng sort in three different localities (not identified). The original site is located on the right bank of the Po-yang-ho, some 100 m north of the main road, in the area of Hui-hui-p'u. Most of the fossils collected were turtles, which were also found at a locality to the north (X on map).

The rocks are a brick red sandstone or fine conglomerate laid down in thick beds; they overlie a late Mesozoic deposit and dip gently

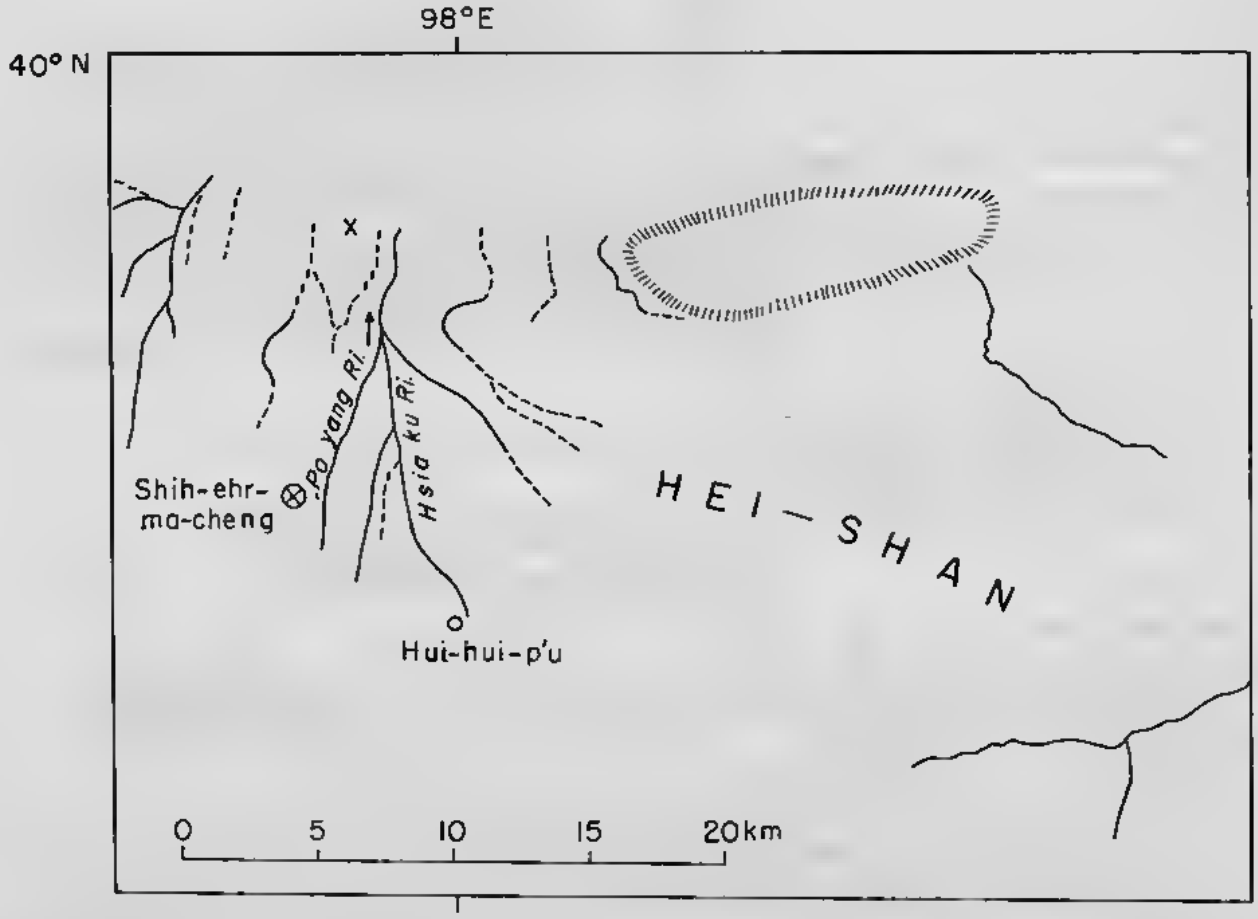


FIG. 209. — Sketch map of the region around Hui-hui-p'u showing the position of the fossil mammal locality at Shih-ehr-ma-cheng. Turtle remains were found in the same red sandstones about 10 km to the north (marked with an X). Modified from Bohlin, 1960.

Source : MNHN, Paris

toward the south. The same kind of sediments occur along the northern border of the Hui-hui-p'u area. The thickness of bed m (Fig. 210) is about 700 m. It is overlain by light brown sandstone and sandy silt also with a thickness of several hundreds of meters. The general dip of the Tertiary deposits is southwest.

In Bohlin's opinion the Shih-ehr-ma-ch'eng mammals were too peculiar for comparisons to be profitably made of them, which left open the question of their age as well as their relationships. Judging from their appearance, however, he added that they probably dated from the earlier half of the Tertiary. McKenna (1963), in an analysis of anagalids, remarked that their age was likely to be younger than early Oligocene, but Wood (1959) suggested a Paleocene age on the basis of *Mimolagus*, thought to be a primitive *Eurymylus*-like lagomorph. *Mimolagus* is now considered to be a true lagomorph of a rather specialized sort (Bleefeld and McKenna, 1985). This opinion strengthens the supposition that the Shih-ehr-ma-ch'eng vertebrates are from the Oligocene, but the faunal evidence is too meager for further precision.

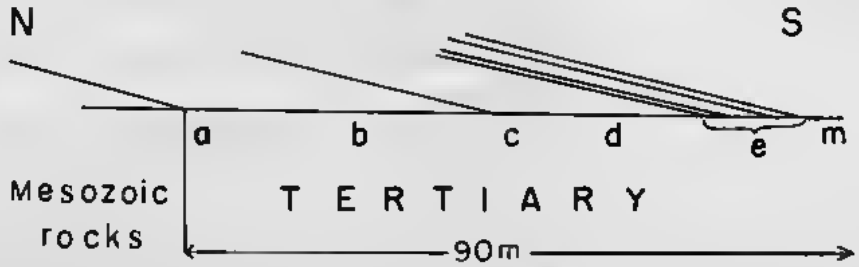


FIG. 210. — Section taken on the east side of the Po-yang River in the region of Shih-ehr-ma-cheng near the northern border of the Hui-hui-p'u badlands, Gansu. a, base of the Tertiary, represented by a lamella of purple sediments; b, finely lamellated grayish brown, or light salmon red, sandy silt; c, a thin bed of wine red clay or silt; d, same as b; e, an alternation of beds b and c, overlain by brick red sediments. Modified from Bohlin, 1960.

Fauna of Shih-ehr-ma-ch'eng

ANAGALIDA
ANAGALIDAE — *Anagalopsis kansuensis* Bohlin, 1951
LAGOMORPHA?
MIMOTONIDAE? — *Mimolagus rodens* Bohlin, 1951
ARTIODACTYLA? Indet.; cited by Bohlin, 1951

Lat. 40° 05′ N
Long. 107° 53′ E

Fig. 2, n° 30

CHINA
NEI MONGOL AUTONOMOUS REGION
Qianlishan District

Yikebulage Fm. **late Oligocene**
Locality: Yikebulage Dadui

For more information on the Qianlishan District and its sediments, refer to the discussion of the middle Oligocene Wulanbulage Formation.

The Yikebulage Formation comprises the middle part of the Tertiary sedimentary sequence in the Yikebulage area. It is composed of

Source : MNHN, Paris

brownish red sandy and silty mudstone, light orange sandstone and sandy gravel intercalated with layers of brownish red mudstone. The thickness of the formation (at the Yikebulage section) is 58 m. It is underlain conformably by the middle Oligocene Wulanbulage Formation and overlain uncomformably by rocks possibly of Miocene age.

Most of the fossil mammals collected from the Yikebulage Formation were also found at Taben Buluk and Shargaltein Gol (Shih-chiang-tzu-ku). They might be regarded as contemporary. The fact that the Yikebulage Formation overlies the Wulanbulage Formation indicates that the age of the Yikebulage Formation may be late Oligocene.

Fauna of the Yikebulage Fm.

INSECTIVORA

ERINACEIDAE

— *Amphechinus* cf. *rectus* (Matthew & Granger, 1924b); cited by Wang *et al.*, 1981, V.P. (1)
(= *Amphechinus? rectus* (Matthew & Granger, 1924b) Butler, 1948)
(= *Palaeoscaptor rectus* Matthew & Granger, 1924b)
— *Amphechinus minimus* Bohlin, 1942) Butler, 1984
(= *Palaeoerinaceus minimus* Bohlin, 1942)
(= *Parvericius montanus* Kœrner, 1940, *in* Rich & Rasmussen, 1973)
(= *Palaeoerinaceus kansuensis* Bohlin, 1942, *in* Rich & Rasmussen, 1973)
(= *Amphechinus kansuensis* (Bohlin, 1942); cited by Wang *et al.*, 1981, V.P. (1))
— *Amphechinus* sp.; cited by Wang *et al.*, 1981, (1)

LAGOMORPHA

OCHOTONIDAE

— *Desmatolagus* sp.; cited by Wang *et al.*, 1981, V.P. (1)
— *Sinolagomys kansuensis* Bohlin, 1937; cited by Wang *et al.*, 1981, V.P. (1)
— *Sinolagomys major* Bohlin, 1937; cited by Wang *et al.*, 1981, V.P. (1)
— *Sinolagomys gracilis* Bohlin, 1942; cited by Wang *et al.*, 1981, V.P. (1)
— *Sinolagomys* sp.; cited by Wang *et al.*, 1981, V.P. (1)

LAGOMORPHA Indet.; cited by Wang *et al.*, 1981, V.P. (1)

RODENTIA

TSAGANOMYIDAE

— *Tsaganomys* sp.; cited by Wang *et al.*, 1981, V.P. (1)

CASTORIDAE Indet.; cited by Wang *et al.*, 1981, V.P. (1)

TACHYORYCTOIDIDAE

— *Tachyoryctoides kokonorensis* Li & Qiu, 1980, V.P. (3); cited by Wang *et al.*, 1981, V.P. (1)
— *Tachyoryctoides obrutschewi* Bohlin, 1937; cited by Wang *et al.*, 1981, V.P. (1)

CTENODACTYLIDAE

— *Tataromys* cf. *sigmodon* Matthew & Granger, t923d; cited by Wang *et al.*, 1981, V.P. (1)
— *Tataromys* cf. *plicidens* Matthew & Granger, 1923d; cited by Wang *et al.*, 1981, V.P. (1)
— *Tataromys deflexus* Teilhard de Chardin, 1926; cited by Wang *et al.*, 1981, V.P. (1)
— *Tataromys* cf. *grangeri* Bohlin, 1946; cited by Wang *et al.*, 1981, V.P. (1)
— *Tataromys suni* Li & Qiu, 1980, V.P. (3); cited by Wang *et al.*, 1981 (1)

Source : MNHN, Paris

DIPODIDAE
— *Parasminthus parvulus* Bohlin, 1946; cited by Wang *et al.*, 1981, V.P. (1)
— *Parasminthus tangingoli* Bohlin, 1946; cited by Wang *et al.*, 1981, V.P (1)

Lat. 44° 15′ N, approx.
Long. 86° 00′ E, approx.

Fig. 2, n° 34

CHINA
XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)
South Junggar Basin

"brown" formation **late Oligocene**

Locality: Hongshan Farm

The locality at which *Dzungariotherium* was discovered by an IVPP team in 1964 is situated 40 km south of the town of Anjihai[8], on the east bank of the Holgos[9] River. The locality, southwest of Hongshan farm, at which *Lophiomeryx* was collected, crops out in the same beds. The fossiliferous sediments consist of clay, sand and sandy clay and attain a thickness of 350-500 m. The fossils were collected from the upper part of the formation. It has received no formational name; references in which it is cited as the lower formation of the Changi Series are in error as the latter contains only Neogene deposits (see Zhai, 1977a). The "brown"[10] formation overlies the late Eocene "lower green" formation and is overlain by the "upper green" of the Changi Series. As with the "lower green" formation, it forms part of the Manas syncline, just north of the Tian Shan Mountains.

Correlation of the "brown" formation is based on the very advanced condition of the *Lophiomeryx* specimen: large size, hypsodont teeth with the metaconid and metastylid nearly closed, all characters that make it appear to be younger than the lower and middle Oligocene forms. The *Dzungariotherium* species is more specialized than *Indricotherium transouralicum*, but a little less than *Paraceratherium*.

Fauna of the "brown" formation

PERISSODACTYLA
HYRACODONTIDAE
— *Dzungariotherium orgosensis* Chiu, 1973, V.P. (2)

ARTIODACTYLA
GELOCIDAE
— *Lophiomeryx* sp.; cited by Chiu, 1965, V.P. (4)

8 Anjihai (= Ansihai).
9 Holgos (= Orgos).
10 "brown" (= hese).

Source : MNHN, Paris

Lat. 42° 30′-43° 30′ N
Long. 88° 00′-92° 00′ E

Fig. 2, n° 1

CHINA
XINJIANG UYGUR AUTONOMOUS REGION
(Sinkiang)
Turpan Basin

upper part of the Taoshuyuanzi Fm. **late Oligocene**

Locality: Feiyue

In 1958, during construction of the Urumqi-Lanzhou railroad, workers found "a great number" of fossil bones. But all the fossils were badly shattered by the blasting of the enclosing rock, which was used as foundation for the track. The original site of the discovery was given as being in the Hami Basin, although more than 200 km separated the locality from the city of Hami. During the IVPP expeditions of 1964 and 1966 to Xinjiang it was decided that, sedimentarily, the fossil locality was situated in part of the Turpan Basin, which is separated from the Hami Basin by rocks of pre-Tertiary age. Also, in the article first describing these remains, the name of Chichaoching[11] was used, but this was before other names were available, as Chichaoching is located in Paleozoic rocks, far from Cenozoic sediments. The Taoshuyuanzi[12] Formation is widely distributed in the eastern part of the Turpan Basin and the fossils are scattered over a large region. Chosing a locality name is rather illusory (locs. 64081, 64080, 64082, for example, are only representatives); in order to prevent confusion with the tiny railroad stations that have furnished names for the Dabu and Shisanjianfang Formations we will use the station name of Feiyue[13] as the general locality of these fossils.

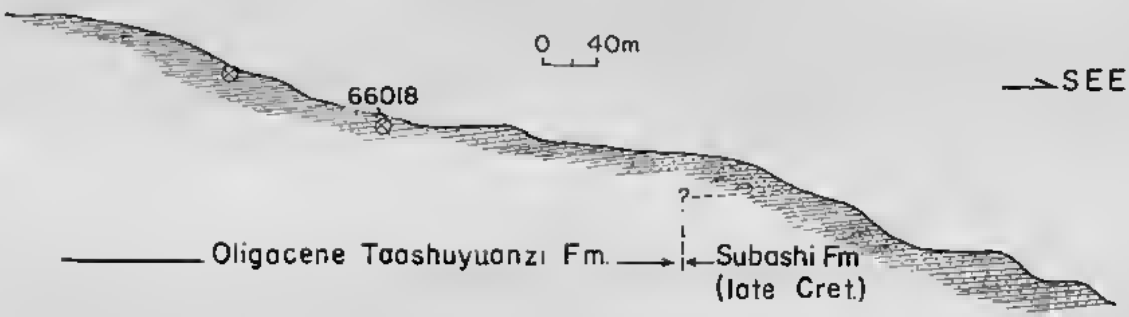


FIG. 211. – Cross section taken at about 48 km south of Shisanjianfang Station in the Turpan Basin, Xinjiang. *Cadurcodon ardynensis* was discovered at the locality 66018 in the lower part of the Taoshuyuanzi Fm. Modified from Zhai *et al.*, 1978.

All the fossils, including those collected by the IVPP, were found in the upper part of the Taoshuyuanzi Formation, with one exception. In the lower part was found a specimen of *Cadurcodon ardynensis* (at loc. 66018), which suggests an early Oligocene age. Lithologically, the formation is difficult to subdivide; in general, it is composed of sandy clay with lenses of dark gray gravel. The lower part is slightly darker in color than the upper, and, at the top of the section,

11 Chichaoching (= Chichaiching); both are misspelled in Pinyin; the correct name is Qi (seven) jiao (angle) jing (well), Qijiaojing, the 7-sided well.
12 Taoshuyuanzi = peach tree orchard.
13 Feiyue = leap.

Source : MNHN, Paris

north of the Dabu station, gray green marl and marly clays crop out.The dip of the beds is very low, so that it was not possible to measure directly the thickness of the formation, but it was calculated to be more than 800 m. Underlying it on the western part of the basin is the late Eocene Liankan Formation; overlying it is the Neogene Putaogou[14] Formation. In the eastern part Oligocene sediments form the surface of the basin.

The fauna of the upper part of the Taoshuyuanzi Formation correlates rather well with the Gansu faunas described by Bohlin from Taben Buluk and Yindirte. The latter have recently been shown to contain a number of elements somewhat older than those of the early Miocene (Li & Qiu, 1980), so that the IVPP regards these to be late Oligocene age, and the upper part of the Taoshuyuanzi Formation as well. Since it is difficult to delimit subunits in the formation, it is, for the present, given as extending from early to late Oligocene.

Fauna of the Taoshuyuanzi Formation (upper part)

INSECTIVORA

ERINACEIDAE
- — *Amphechinus* cf. *rectus* (Matthew & Granger, 1924b); cited by Zhai, 1978c
  (= *Palaeoscaptor rectus* Matthew & Granger, 1924b, *in* Butler, 1948)
- — *Amphechinus*? sp.; cited by Zhai, 1978c

LAGOMORPHA

OCHOTONIDAE
- — *Sinolagomys kansuensis* Bohlin, 1937; cited by Zhai, 1978c

RODENTIA

CTENODACTYLIDAE
- — *Tataromys* cf. *sigmodon* Matthew & Granger, 1923d; cited by Zhai, 1978c

CREODONTA

HYAENODONTIDAE?
- — *Hyaenodon*? sp.; cited by Zhai, 1978c

PERISSODACTYLA

CHALICOTHERIIDAE
- — *Schizotherium* sp.; cited by Zhai, 1978c

HYRACODONTIDAE
- — *Aceratherium*? sp.; cited by Zhai, 1978c
- — *Paraceratherium tienshanensis* Chiu, 1962, V.P. (1)
  (= *Indricotherium* cf. *grangeri* (Osborn, 1923a; cited by Chow & Xu, 1959, V.P. (2))
- — *Paraceratherium lipidus* Xu & Wang, 1978
- — *Dzungariotherium turfanensis* Xu & Wang, 1978

ORDER Indet.

DIDYMOCONIDAE
- — *Didymoconus berkeyi* Matthew & Granger, 1924a; cited by Zhai, 1978c

Fauna of the Taoshuyuanzi Fm. (lower part)

PERISSODACTYLA

AMYNODONTIDAE
- — *Cadurcodon ardynensis*[15] (Osborn, 1923c) Kretzoi, 1942; cited by Zhai, 1978c
  (= *Cadurcotherium ardynense* Osborn, 1983c)

14 Putaogou = grape valley.

15 This form is representative of the early Oligocene, although it is known at one middle Oligocene locality. Its presence here suggests that this part of the Taoshuyuanzi Fm. is older than late Oligocene.

Source : MNHN, Paris

Lat. unknown
Long unknown

CHINA

Nei Mongol Autonomous Region

Ordos Region

formation unknown **Oligocene**

Locality unknown

Two species of chalicothere were cited by Hu (1959) from a locality somewhere in the Ordos region. The exact whereabouts of this site is presently unknown.

No information is available concerning the sediments.

Fauna

PERISSODACTYLA

Chalicotheriidae

— *Schizotherium ordosium* Hu, 1959
— *Schizotherium* cf. *avitum* Matthew & Granger, 1923b; cited by Coombs, 1978
(= *Schizotherium avitum* Matthew & Granger, 1923b; cited by Hu 1959)

Lat. 23° 30′ N, approx.
Long. 69° E, approx.

INDIA

Gujarat State

Kachchh

Bermoti Series: Waior Stage **Late Oligocene**

Locality: Matanomadh

For details on the fossiliferous Tertiary deposits of Kachchh[16], the reader is referred to the section on the middle Eocene of the Berwali Series.

The Oligocene Bermoti Series is composed of arenaceous marls; it is overlain by a thick sequence of Mio-Pliocene sandstones and carbonates and underlain by the Berwali Series. The late Eocene is represented by a hiatus. An upper (Waior) and a lower (Mamania) Stage have been recognized.

Vertebrates in the form of sirenian ribs, vertebrae and mandibular fragments, were found in a bioclastic limestone situated in the upper part of the Waior Stage.

16 Kachchh = Kutch.

Source : MNHN, Paris

Fauna of the Bermoti Series

SIRENIA

DUGONGIDAE — *Halitherium* sp.; cited by Sahni & Mishra, 1975

Lat. 33° 14′ N, approx.
Long. 129° 40′ E, approx. Fig. 129, n° 6

JAPAN
KYUSHU
Nagasaki Prefecture

Nakazato Fm. **Oligocene?**
Locality: Ikeno

In 1925, Matsumoto described a new species of anthracothere, *Brachyodus japonicus*, from the lower part of the Sasebo Group near the city of Sasebo, in northwestern Kyushu[17]. He regarded it as representing an early or middle Oligocene age. The specimen was found in the Ikeno Coal Mine within the Kitamatsu Coal field and reportedly came from the Nakazato beds, which were said to occur near the middle of the Matuura Formation. Takai (1961) and Takai and Tsuchi (1963) accord the Nakazato beds formational status and situate them in the lower part of the Sasebo Group. A series of six formations compose this group, the bottom one being the Ai-

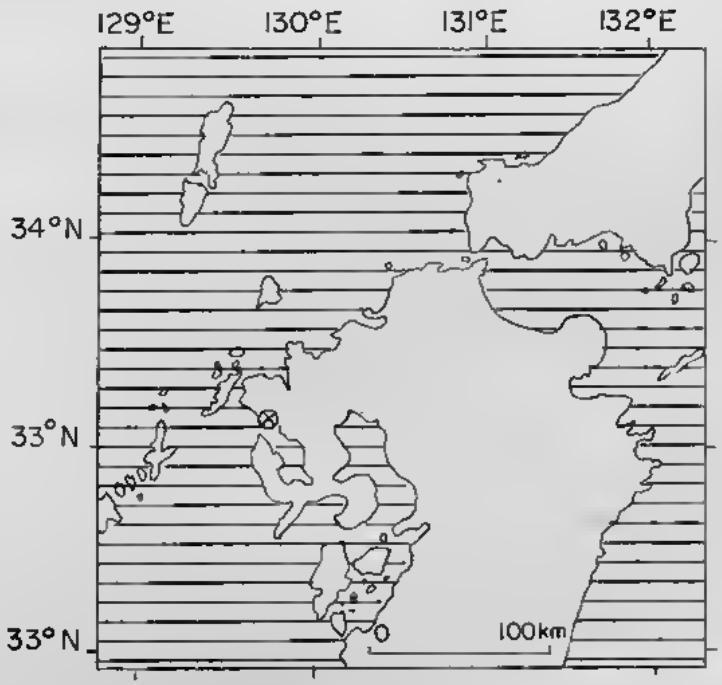


FIG. 212. Sketch map of the western part of the island of Kyushu, Japan, showing the Ikeno Coal Mine locality (in the Kitamatsu coal field) near Sasebo, Nagasaki Prefecture. Modified from Otsuko, 1979.

17 Kyushu (= Kuysyu = Kiushu).

Source : MNHN, Paris

noura; the Nakazato Formation overlies it and in turn is overlain by the Yunoki Formation. These formations vary little in facies and thickness and are chiefly alternations of sandstone and shale, often intercalated with coal and tuff layers. They yield abundant molluskan and plant remains.

Takai in 1939b argued against an Oligocene age for the sediments and considered them early Miocene, based on the assumption that the anthracothere represented the genus *Brachyodus*.

In a thesis comprising a detailed study of *Brachyodus* and defended in Paris in 1981 (but not published), H. Dineur noted that "*Brachyodus*" *japonicus* was very probably referable to *Elomeryx*. From this attribution he concluded that the beds from which it came were much more probably Oligocene than Miocene.

Tomida (1983, pers. com.) revealed that "recent studies of the area indicate (that the fossiliferous beds are) early — middle Miocene".

The situation remains unclear.

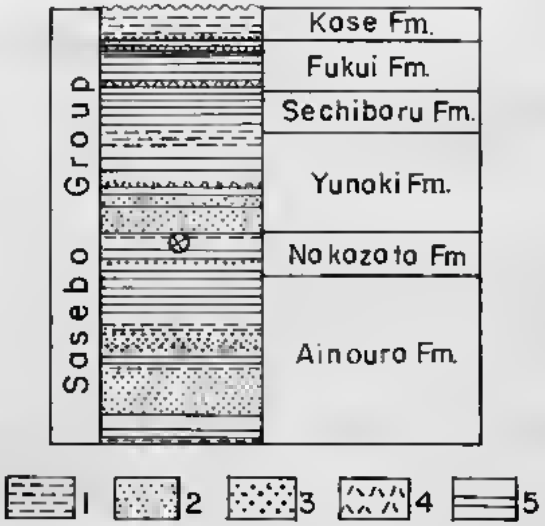


FIG. 213. — Section through the sediments of the Sasebo Group near Sasebo, Kyushu, Japan. The level that furnished the mammalian fossil is indicated in the Nakazato Fm. **1.** mudstone; **2.** sandstone; **3.** conglomerate; **4.** tuff or tuff breccia; **5.** coal or coaly shale. Modified from Otsuka, 1979.

Fauna of the Nakazato Fm. at Ikeno

ARTIODACTYLA

ANTHRACOTHERIIDAE — "*Brachyodus*" *japonicus* Matsumoto, 1925

Lat. 44° 23′ N, approx.
Long. 77° 55′ E, approx.

Fig. 3, n° 6

U.S.S.R.
KAZAKH S.S.R.
Taldy-Kurgan Oblast'

Aktau Svita **late Oligocene**

Locality: Sary-Ozek Station

Mammalian fossils were found in the southwestern part of the Dzhungarian Alatau mountain range near Sary-Ozek [18], a station on the Turkestan-Siberian railroad (Fig. 198, p. 346), in 1956 and 1958 by Bazhanov and Kostenko. Situated in a gravel quarry 2 km southwest of the station, the locality yielded the lower jaw of a large entelodontid and the cervical vertebra of a gigantic hyracodontid.

The fossiliferous gravels are overlain by Pliocene sediments and separated from them by an erosional surface at an angle of about 30°.

This locality is often attributed to the early Miocene, which, according to the meager faunal

18 Sary-Ozek = small natural basin with yellow water.

Source : MNHN, Paris

evidence (see Bazhanov & Kostenko, 1958) could indeed be possible. But it is intimately associated in the literature with the fauna at Aktau, 55 km to the southeast. The principal argument for considering Sary-Ozek Station as belonging to the late Oligocene is the affirmation that stratigraphically its fossil-bearing bed is the same as that comprising the upper horizon at Aktau; there is a faunal argument for regarding the latter as late Oligocene.

Note that Sary-Ozek Station in the Dzungharian Alatau is rather distant from the Sary-Ozek River locality near the northeast shore of Lake Balkhash.

Fauna of the Aktau Svita at Sary-Ozek Station

PERISSODACTYLA

HYRACODONTIDAE — *Paraceratherium prohorovi* (Borisyak, 1939) Gromova, 1959; cited by Savinov, 1963
(= *Aralotherium prohorovi* Borisyak, 1939)

ARTIODACTYLA

ENTELODONTIDAE — *Neoentelodon dzhungaricus* Aubekerova, 1969

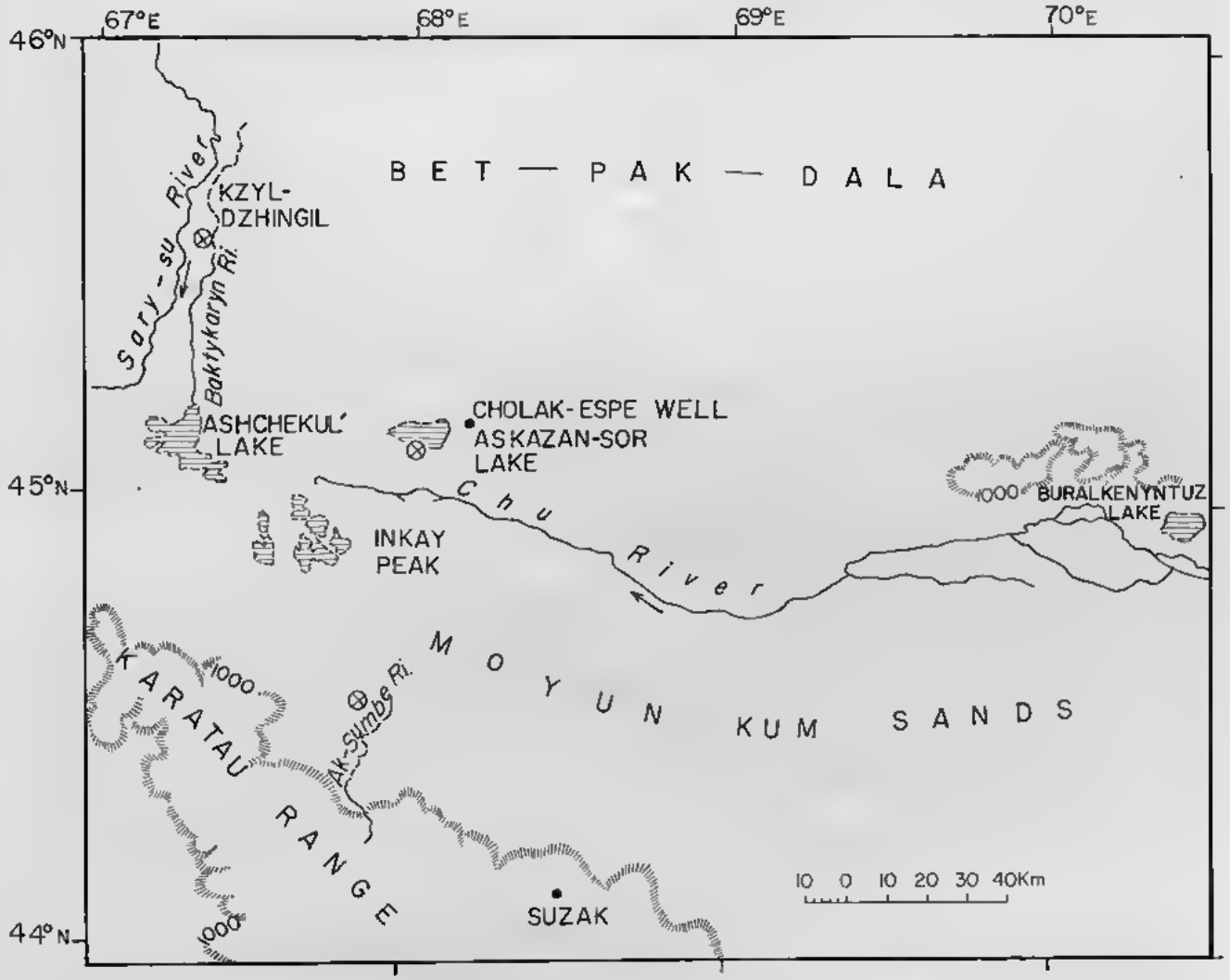


FIG. 214. — Southwestern region of the Bet-Pak-Dala, Kazakh S.S.R., showing the localities of As kazan-Sor, Kara-Tau (near the Ak-Sumbe River) and Sary-Su (between the Sary-Su and Boktykaryn Rivers). Modified from a map provided by G. V. Shkurkin.

Source : MNHN, Paris

Lat. 45° 8′ N, approx.
Long. 68° E, approx.

Fig. 3, n° 14

U.S.S.R.
KAZAKH S.S.R.
Chimkent Province
Betpakdala Steppe

Askazansor Svita — **late Oligocene**

Locality: Askazan-Sor

Bountiful remains of fossil mammals are associated with the Askazansor Svita[19] and are found at several sites in the Bet-Pak-Dala[20]. That which has produced the largest assemblage is located at the salt pan of Askazansor[21], situated about 300 km east of Kzyl-Orda[22], the

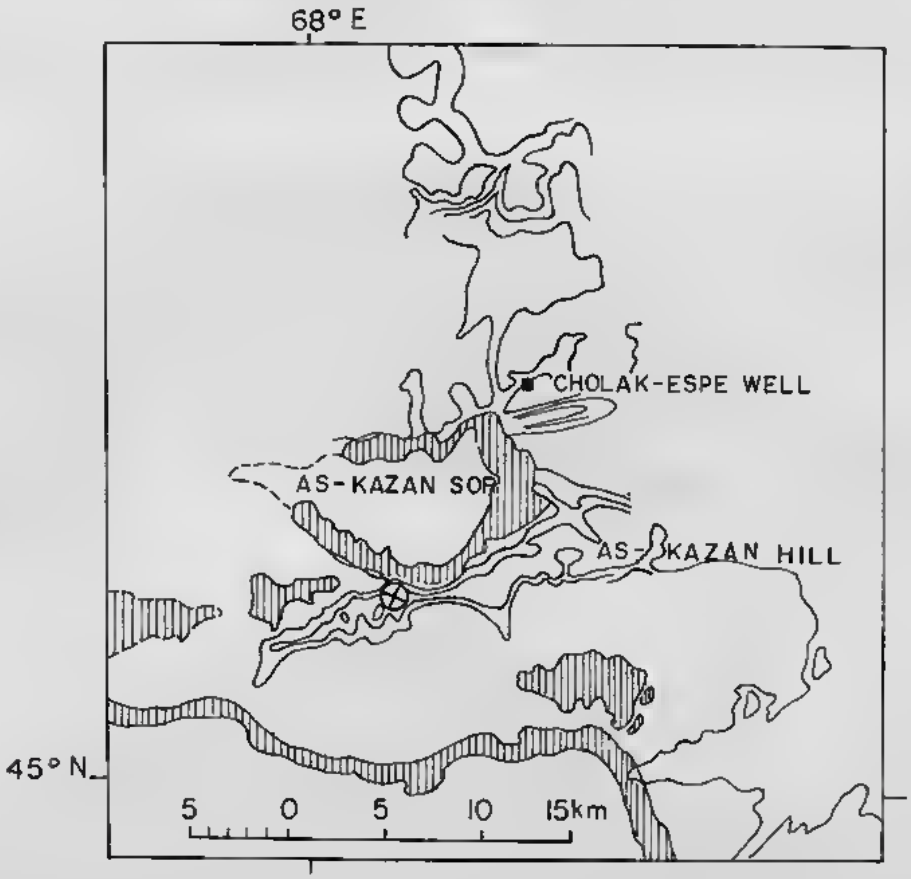


FIG. 215. Details of the Askazan-Sor area, Kazakh S.S.R., showing the fossil locality at its southern edge. Modified from Orlov, 1941.

19 Askazansor = an area with the shape of a kettle containing a healing mud.
20 Bet-Pak-Dala (= Betpakdala = Betpak-dala = Betpak-Dala) = flat, expressionless face, steppe. Also known as the Golodnaya (= famine) Steppe.
21 Askazansor (= As-kazan-Sor = As-Kazanyn-Sor).
22 Kzyl-Orda (= Kyzyl Orda) = Red Army.

Source : MNHN, Paris

former city of Perovsk. The locality is on the south shore of the large (more than 150 sq. km) salt pan called Askazan-Sor; the excavations were made on the NW slope of Askazan Mesa. Collections were first made in the area in 1929 by Yakovlev and in 1934 by Selevin; in 1936 excavations were carried out under the direction of Orlov, and in 1958-1959 that of Biryukov and Bazhanov. The latter referred to the mammals collected as the *Phyllotillon* fauna because of the dominance of that animal. The vertebrate material is in a thin conglomeratic bed (also called a cemented yellow gravel) and was badly fragmented due to rapid 'water transport damage. Considerable difficulty was encountered in extracting the disassociated bones due to the indurated matrix. Also due to the conditions of deposition, only a single rodent incisor, representing the micromammal community, was seen.

Detailed section in Askazan Mesa, made during the 1936 excavations:

1.	top soil	10 cm
6.	greenish gray sand	20-40 cm
5.	greenish gray clay with stringers of sand	40-50 cm
4.	argillaceous sands, greenish gray	1.5-2 m
3.	conglomerate, buff, with coarse sand, gravel, grit and lumps or lenses of clay, with mammal bones	10-40 cm
2.	yellow, gray sands	up to 25 m
1.	greenish gray clay for tens of meters: forms the lower half of the mesa.	

The Askazansor Svita is exposed along the Kara-Tau Range and crops out extensively in the region of the Chu River: in the lower reaches around the promontory of In-Kay[23] (it is also exposed about 20 km to the east among the aeolian sands of the Moyunkum[24] Desert); along the right bank stretching far to the east (including the locality of Saroy), nearly to the Karchingaly River; and, on the same bank, to the west as far as the left bank of the lower reaches of the Sary-Su River. It is well exposed in the large cliffs on the left bank of the Boktykaryn River, where it overlies red clays of the middle Oligocene.

Its sediments are light gray, greenish gray or ochre quartzitic and mica-quartzitic, fine-grained sands with lenses and stringers of variegated clays and also of quartzitic and ferruginous limestones and gravelites. Variegated sandy clays and yellow-gray or blueish quartz-mica silts sometimes assume an important part in the composition of the section.

The origin of the Askazansor Svita is presumed to have been due to lake or river alluvial fill. For example, east of the Buralkenyntuz salt pan, its sediments apparently filled an ancient valley that was about 25 m wide (see the Saroy locality). The greatest thickness of the svita occurs on the south flank of the Askazansor salt pan (42 m) and in the piedmont of the Kara-Tau Range at Kyzyl-Zhar well (52 m); generally, it does not exceed 15-20 m. In the area of the Buralkenyntuz salt pan the Askazansor Svita unconformably overlies red-buff gypsiferous middle Oligocene clays, or Eocene deposits, or various rocks of Carboniferous age.

The Askazansor fauna can be correlated with that of Agyspe on the Aral Sea and both have been considered by various workers as either late Oligocene or early Miocene. More information is needed, but they are tentatively retained in the late Oligocene.

Musakulova (1971) indicated the existence of a locality, 20 km to the NE of the classic Askazansor site, that was excavated by personnel of the Institute of Paleozoology at Alma Ata. Since the Askazansor Svita crops out in the cliffs along the Boktykaryn River, along with the middle Oligocene indricothere beds, the unnamed locality, which is approximately midway between Askazansor and the Boktykaryn cliffs, could be of either age.

23 In-Kay = whistling (?) grotto.
24 Moyunkum = quicksand in which one sinks up to the neck

Source : MNHN, Paris

Fauna of the Askazansor Svita at Askazan-Sor

RODENTIA Indet.; cited by Orlov, 1941

CARNIVORA

FELIDAE — Machairodontinae indet.; cited by Orlov, 1941

AMPHICYONIDAE Indet.; cited by Orlov, 1941

CARNIVORA Indet. (2 small forms); cited by Orlov, 1941

PERISSODACTYLA

CHALICOTHERIIDAE — *Borissiakia betpakdalensis* (Flerov, 1938) Butler, 1965
(= *Moropus betpakdalensis* Flerov, 1938)
(= *Phyllotillon? betpakdalensis* (Flerov, 1938), *in* Borisyak, 1940; see also Borisyak, 1946)
(= *Phyllotillon betpakdalensis* (Flerov, 1938), *in* Borisyak 1944b and Belyayeva, 1954b)

HYRACODONTIDAE — *Indricotherium* or *Paraceratherium* sp.; cited by Gabunia, pers. com., 1980
— *Aprotodon borissiaki* Belyayeva, 1954a

RHINOCEROTIDAE — *Brachypotherium* sp.; cited by Orlov, 1941
(= *Brachypotherium askazansorense* Belyayeva 19 ?, *nomen nudum*?; cited by Belyayeva, 1964)
— *Dicerorhinus minutus* (Cuvier, 1824) de Bonis, 1973
(= *Rhinoceros minutus* Cuvier, 1824)
(= *Ceratorhinus tagicus* Roman, 1911; cited by Orlov, 1941)

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Hemimeryx turgaicus* Borisyak, 1941
— *Anthracotherium* sp.; cited by Orlov, 1941

SUIDAE — *Conohyus betpakdalensis* Trofimov, 1949

GELOCIDAE — *Lophiomeryx turgaicus*[25] Flerov, 1940; cited by Musakulova, 1971
— *Prodremotherium* sp.; cited by Musakulova, 1971

25 This taxon is considered as a *nomen nudum* by Trofimov (pers. com., 1981). It is not certain that this and *Prodremotherium* are from the Askazan-Sor fauna.

Source : MNHN, Paris

FIG. 216. -- Southeastern region of the Bet-Pak-Dala, Kazakh S.S.R., showing the Chu River valley and the Saroy Depression. Oligocene sediments occur along the northern boundary of the latter and extend westward to below the Buralkenyntuz-Sor. On the left bank of the Chu the Oligocene deposits crop out above and west of Zhalanash Lake. The altitude contours are in meters. Modified from a map provided by G. V. Shkurkin.

Lat. 44° 55′ N, approx.
Long. 71° 40′-72° E, approx.

Fig. 3, n°10

U.S.S.R.
KAZAKH S.S.R.
DZHAMBULSK OBLAST'

Askazansor Svita — **late Oligocene**

Locality: Saroy

A first report on the discovery of fossil vertebrates in the small basin (or depression) of Saroy was made by the geologist Eliseyev (or Yeliseyev) in 1958. The bones and teeth were

Source : MNHN, Paris

found during field work essentially devoted to the search for diamonds. More extensive fossil collections were made by Eliseyev in 1966.

Late Oligocene fluviatile deposits representing the Askazansor Svita in the southeastern part of the Bet-Pak-Dala consist of brown conglomerates, yellow crossbedded sands containing gravel and pebbles, small interbeds of calcareous sandstones, yellow sands and yellowish brown and green clays. All the types of sediment contain various quantities of gypsum. The series of rocks lies on a deeply eroded surface of Paleozoic formations.

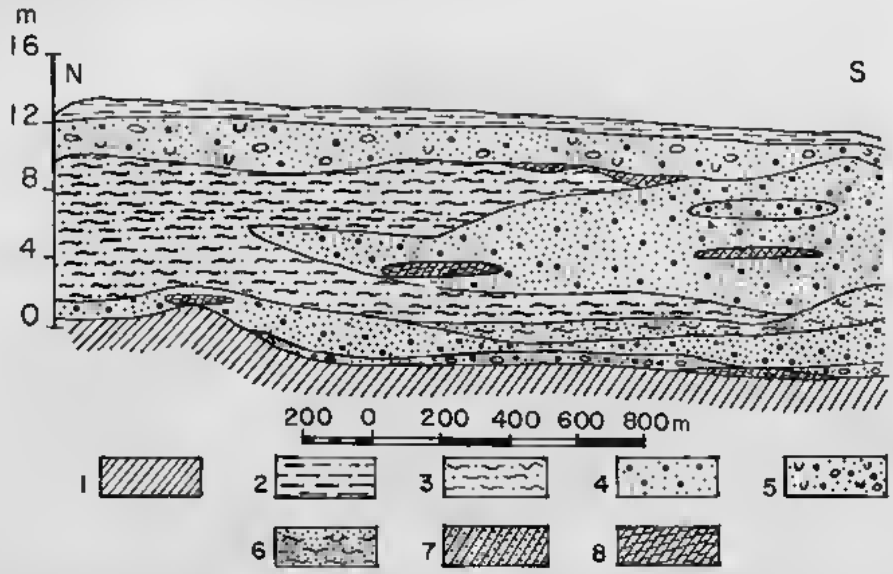


FIG. 217. Structure of the late Oligocene alluvial sequence in the western part of the Saroy Depression, Kazakh S.S.R., 1. Paleozoic sediments; 2. loam; 3. sandy clay; 4 sand with gravel; 5. sand with gravel and gypseous gravels; 6. argillaceous sand; 7. sandstone; 8. gravel or conglomerate. Modified from Eliseyev, 1958.

The sequence in the Saroy Depression is as follows:

Quaternary sediments or early to middle Miocene conglomerates very similar to the basal conglomerates cited below; fossiliferous	1-2 m
Yellow-brown and green sandy micaceous, calcareous clays	2-4 m
Yellow quartzitic, micaceous sand locally containing gravel with lenses and interbeds of calcareous sandstones; fossiliferous	0.05-1 m
Basal conglomerates, mostly fragments of sandstone dispersed in a yellow quartzitic, micaceous and locally argillaceous sand; fossiliferous	0,4-1,3 m

The total thickness of the late Oligocene in the eastern part of the Saroy Depression is from 3.5 to 6.4 m and, with much variation, attains a maximum of about 13 m in the west. The conglomerates of both the lower and upper beds and the crossbedded sands contain bone and teeth fragments.

The occurrence of "*Phyllotillon*" *betpakdalensis*, discovered by Shubina south of the minor Ak-Oy[26] Depression, was also reported by Eliseyev (1958). An interesting flora accompanied the chalicotheriid; both are apparently from the Askazansor Svita. Belyayeva and Bazhanov identified the faunal elements found by Eliseyev and listed below, which constitute an extension of the larger assemblage known from the localities near Askazansor and, on this basis, can be considered as late Oligocene.

26 Ak-Oy = white hollow, or depression.

Source : MNHN, Paris

Fauna of the Askazansor Svita at Saroy

CREODONTA

HYAENODONTIDAE — *Hyaenodon* sp.; cited by Kostenko *et al.*, 1971

PERISSODACTYLA

CHALICOTHERIIDAE — *Borissiakia betpakdalensis* (Flerov, 1938) Butler, 1965
(= *Moropus betpakdalensis* Flerov, 1938)
(= *Phyllotillon? betpakdalensis* (Flerov, 1938) Borisyak, 1940)
(= *Phyllotillon betpakdalensis* (Flerov, 1938) Belyayeva, 1954b; cited by Kostenko *et al.*, 1971)

HYRACODONTIDAE — *Indricotherium* sp.; cited by Kostenko *et al.*, 1971
(= Indricotheriidae indet.; cited by Gromova, 1959)

RHINOCEROTIDAE — *Eggysodon turgaicus* (Borisyak, 1915) Brunet, 1979
(= *Epiaceratherium turgaicum* Borisyak, 1915)
(= *Allacerops turgaica* (Borisyak, 1915) Radinsky, 1967; cited by Kostenko *et al.*, 1971)

ARTIODACTYLA

ENTELODONTIDAE Indet.; cited by Kostenko *et al.*, 1971

ANTHRACOTHERIIDAE — *Brachyodus* sp.; cited by Kostenko *et al.*, 1971

U.S.S.R.
KAZAKH S.S.R.
VOSTOCHNO KAZAKHSTANSKAYA OBLAST'
ZAYSAN DEPRESSION

Nura Svita **late Oligocene**

Localities: Kusto River (Shatrovaya); Kyzylkain River (Lisiy Nos); Areal Site V, Aksyir River (Rodnik, or Nad Rodnikom)

Knowledge of the remains of fossil mammals in the Nura[27] Svita is the result of collecting by Chkhikvadze and Shevyreva in the 1960's and 70's on the Kusto, Kyzylkain and Aksyir Rivers.

On the right bank of the Kusto River the Nura Svita is situated unconformably between the Dzhamangora Svita (early Miocene) and the Oshaganda Svita, with varying but steep angles of dip and a thickness of about 20 m. The locality is a hillock called Shatrovaya[28].

Equally on the right bank, but on the Kyzylkain River, the Nura Svita has a more moderate dip and a thickness reduced to about 15 m. Fossil mammals were found on the southwest slope of a hillock that was named Lisiy Nos[29], a little below the Dzhamangora Svita.

On the Aksyir River at the locality Rodnik[30] several mammal-bearing horizons in the svita were discovered on the southern flank of the first Aksyir anticline. As elsewhere, the Nura Svita is unconformably situated between the Dzhamangora and Oshaganda[31] Svitas. Its thickness is from 15 to 20 m and its dip is moderate.

As concern its age, based on the mammalian fauna, identifications are too vague and too few; no conclusion is possible.

27 Nura = circumvolution.
28 Shatrovaya Sopka = tent-shaped hillock.
29 Lisiy Nos = fox nose.
30 Rodnik = spring; Nad Rodnikom = above the spring.
31 Oshaganda = region where plants of the genus *Arctium* (burdock) grow.

Source : MNHN, Paris

Fauna of the Nura Svita

(furnished by Dr. Shevyreva and Dr. Gureyev)

INSECTIVORA Indet.; cited by Gureyev, pers. com., 1981

RODENTIA

CASTORIDAE Indet.; cited by Shevyreva, pers. com., 1981
RHIZOMYIDAE Indet.; cited by Shevyreva, pers. com., 1981

Lat. 46° 47′ N, approx.
Long. 60° 30′ E, approx.

Fig. 3, n° 22

U.S.S.R.
KAZAKH S.S.R.
KYZYL-ORDINSKAYA OBLAST'

Aral' Svita **late Oligocene**

Locality: Agyspe

The locality of Agyspe[23] occurs on the northern shore of the Aral Sea near Perov Bay, 4 km east of the settlement of Agyspe at Kumbulak spring. Originally called the Aral Sea locality, it was discovered in 1925 by Glagovidov and exploited by Alekseyev in 1931, by Prokhorov in 1932-1933 and by Orlov in 1936 and 1938. The fauna is currently being revised by O. Bendu-

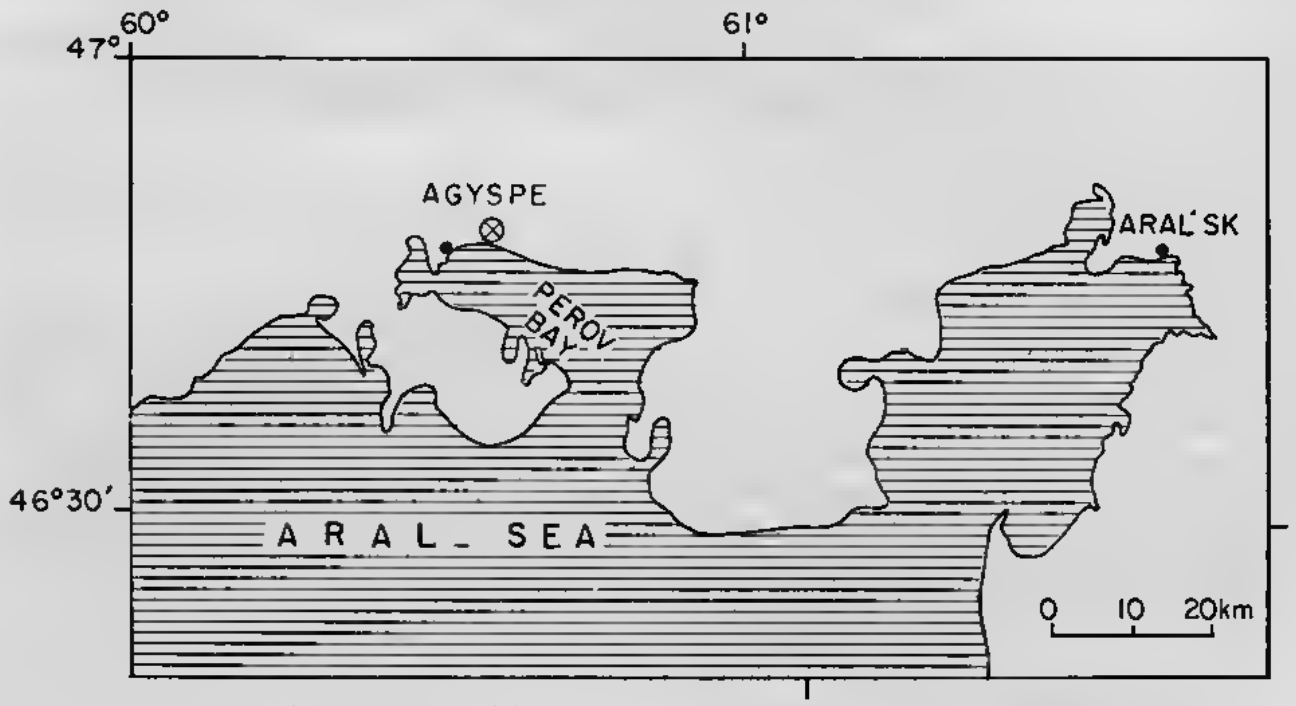


FIG. 218. Detailed map of the north shore of the Aral Sea showing the position of the fossil mammal locality close to the town of Agyspe, Kazakh S.S.R. Modified from the Atlas Mira, 1954.

32 Agyspe (= Akespe) = impetuous mare; (Kumbulak (= sandy spring) refers to the same locality).

Source : MNHN, Paris

kidze of the Institute of Paleobiology, Tbilisi, Georgian S.S.R.

The locality is situated high (160 m above Aral Sea level — in 1938) in the cliff that forms the northern border of Perov Bay. This cliff is undergoing rapid erosion, due to which deep, steep-sided ravines are formed, revealing the section detailed below.

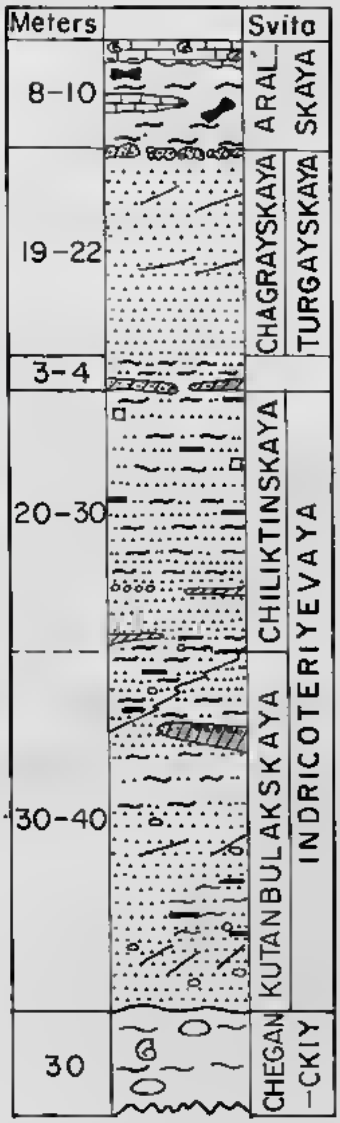


FIG. 219. — Section at Kumbulak on Perovsk Bay, Kazakh S.S.R., showing the succession from the underlying marine clays of the Chegan series, the Indricotherе Svita, overlain by a thin Zhaksylych Svita, by the Chagray, or Turgay Svita, and capped by the Aral' Svita. Modified from Lavrov, 1959.

A new assemblage is being collected from Sayaken[33], in the region of the Gulf of Tshchibas, from the same level of the Aral' Svita, and other fossiliferous sites are known at Kuzhasay[34], Zhilansay[35] and Bestobe[36] on the west coast of the Aral Sea.

The Aral' Svita at Agyspe has been subdivided into six beds:

6. Corbula limestones ..... about 3.5 m
5. greenish marly clay (with concretions)..... ..... about 1 m
4. green clay..... about 2 m
3. green marls ..... about 2 m
2. argillaceous clays ..... about 80 m
1. greenish clays — at the level of the Aral Sea.

Vertebrate remains have been found in the beds n° 4 - 6, but numbers 4 and 5 have furnished most of the material. Two giant hyracodontid skulls were discovered by Alekseyev (only one could be collected, by Prokhorov) in bed 5.

At this level, as in the overlying Corbula limestone, the remains of small mammals appear to be rare. In bed 4, however, small forms are abundant and the bones of big mammals are rare. A chaotic distribution of the fossils prevails in the two top levels, which constitute a veritable bone bed 3.5 to 4 m thick. Orlov (1939) considered beds 4 to 6 to be contemporaneous and representative only of different facies. During the field season of 1938 an area of 275 km² was prospected.

The Aral' Svita is overlain by the sands and sandstones of the Kintyktshe[37] Svita and underlain by the Baygubek Svita. The name Aral' Svita is used for the littoral marine and continental facies of the basal Miocene in the region of the NE Ustyurt plateau and the northern Aral. Various correlation schemes are used for these late Oligocene or early Miocene beds, but certitude about the validity of one choice over another is not feasible here.

The age of the Agyspe fauna has been frequently discussed and regarded either as late Oligocene or as early Miocene (for the latter, see Lavrov *et al.*, 1978). Some have even said that

33 Sayaken = fast stream.
34 Kuzhazay = male lamb stream.
35 Zhilansay = snake ravine.
36 Bestobe = five hill tops.
37 Kintykshe = small navel (?).

Source : MNHN, Paris

the fossiliferous beds were Miocene and that the fauna was reworked from the late Oligocene level. This hypothesis has been firmly discarded by Bendukidze; the fossils and the containing sediments can be considered to be the same age. Bendukidze himself is of the opinion that they are early Miocene and specifies that they are younger than the highest part of the Shand-Gol Svita, which he believes includes both the middle and the late Oligocene[38]. It is undeniable, however, that an important element shows a definite similarity to such late Oligocene assemblages as Feiyue, Yikebulage, Shargaltein Gol and Taben Buluk. The presence in both the Aral' Svita and the late Oligocene sediments of Western Europe of *Eucricetodon*, *Paraceratherium*, *Protapirus*, *Prodremotherium*, *Amphitragulus* and *Lophiomeryx* would also suggest a correlation between the two. We will therefore regard the Agyspe fauna, at least for the time being, as late Oligocene.

Fauna of the Aral' Svita at Agyspe

INSECTIVORA

ERINACEIDAE
- — *Palaeoscaptor acridens* Matthew & Granger, 1924b; cited by Borisyak & Belyayeva, 1948

LAGOMORPHA

OCHOTONIDAE
- — *Desmatolagus* aff. *gobiensis* Matthew & Granger, 1923d; cited by Bendukidze, 1977

RODENTIA

CASTORIDAE
- — *Steneofiber* sp.; cited by Argyropulo, 1940
- — *Agnotocastor* sp.; cited by Bendukidze, pers. com., 1984 (= *Palaeocastor* sp.; cited by Bendukidze, 1977)
- — *Propalaeocastor kumbulakensis* Lychev, 1970: Bendukidze (pers. com., 1984) considers this species referable to *Palaeocastor*)

CRICETIDAE
- — *Eucricetodon* aff. *caducus* (Shevyreva, 1967) Lindsay, 1977 (= *Cricetodon* (aff.) *caducus* Shevyreva, 1967; cited by Gabunia, pers. com., 1980)
- — *Eucricetodon* aff. *asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977 (*Eumys* (aff.) *asiaticus* Matthew & Granger, 192d) (= *Cricetodon* aff. *deploratus* Shevyreva, 1967, *in* Lindsay, 1977; cited by Bendukidze, 1977)
- — *Aralomys gigas* Argyropulo, 1939a
- — *Eumysodon orlovi* Argyropulo, 1939a
- — *Eumysodon spurius* Argyropulo, 1939a
- — *Argyromys aralensis* (Argyropulo, 1939b), Shaub 1958 (= *Schaubeumys aralensis* Argyropulo, 1939b)
- — *Argyromys woodi* (Argyropulo, 1939b), Schaub 1958 (= *Schaubeumys woodi* Argyropulo, 1939b)
- — *Protolactaga borissiaki* Argyropulo, 1939

CARNIVORA

FELIDAE Indet.; cited by Orlov, 1939

PERISSODACTYLA

HYRACODONTIDAE
- — *Aprotodon borissiaki* Belayeva, 1954a
- — *Aceratherium aralense* Borisyak, 1944a
- — *Paraceratherium prohorovi* (Borisyak, 1939) Gromova, 1959 (= *Aralotherium prohorovi* Borisyak, 1939)
- — *Protaceratherium* sp.; cited by Bendukidze, 1977

38 Note that Goroshko & Kurochkin (1979) say that in no case can a late Oligocene age for part of the Shand-Gol sediments be confirmed palaeontologically.

Source : MNHN, Paris

RHINOCEROTIDAE

— *Eggysodon* sp.
(= *Allacerops* sp.; cited by Bendukidze, 1977)

ARTIODACTYLA

GELOCIDAE

— *Lophiomeryx* sp.; cited by Orlov, 1939
— *Prodremotherium* sp.; cited by Musakulova, 1971
(= *Prodremotherium*? sp.; cited by Orlov, 1939)
— *Miomeryx* sp.; cited by Musakulova, 1971
(= *Miomeryx*? sp.; cited by Orlov, 1939)
— *Amphitragulus* sp.; cited by Gabunia, pers. com., 1980
— *Amphitragulus boulangery* Abdrakhmanova, 1973, *nomen nudum*
— *Micromeryx flourensianus* Abdrakhmanova, 1973, *nomen nudum*

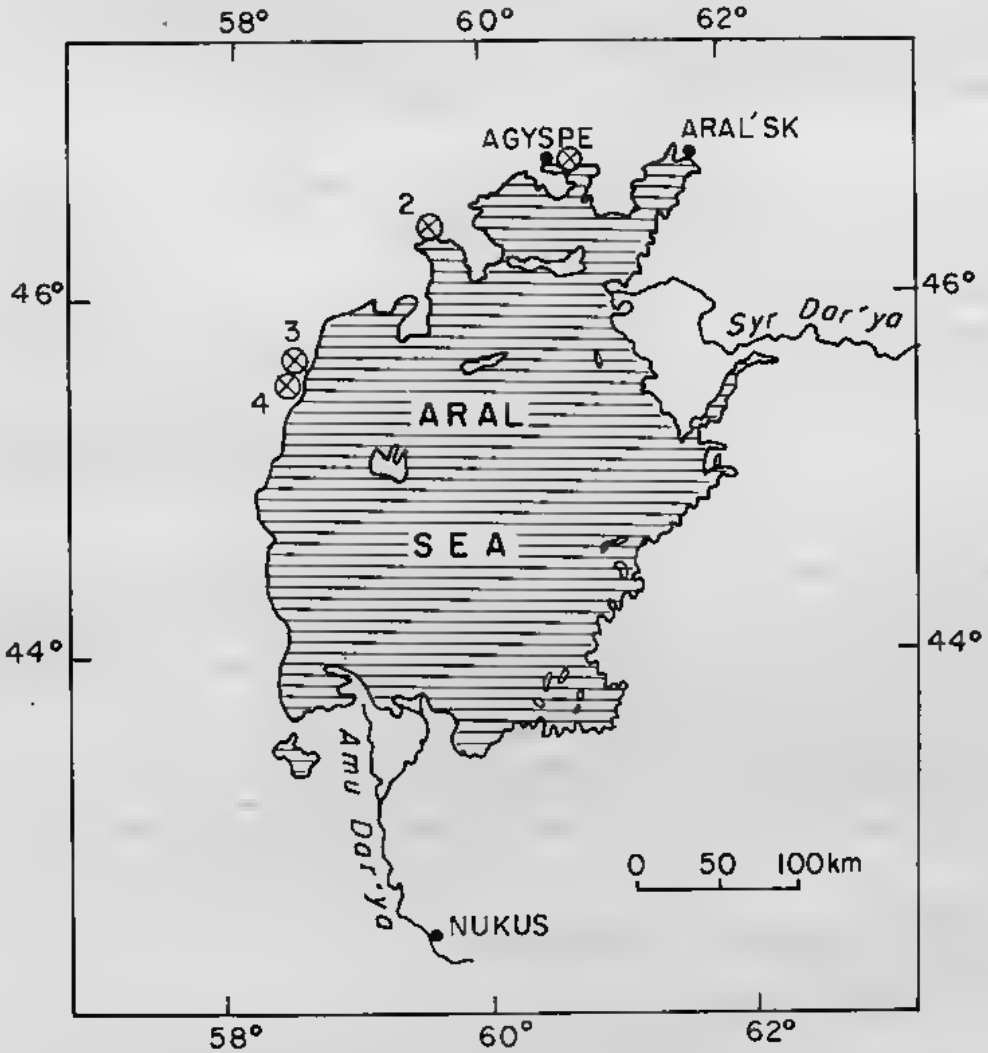


FIG. 220. — Map of the late Oligocene localities near the Aral Sea, showing: **1**. Agyspe; **2**. Sayaken; **3**. Kuzhasay; **4**. Zhilansay. Modified from a sketch provided by O. G. Bendukidze.

Source : MNHN, Paris

Lat. 46° 22′ N, approx.
Long. 59° 32′ E, approx.

Fig. 3, n° 23

U.S.S.R.
KAZAKH S.S.R.
Kyzyl-Ordinskaya Oblast'

Aral' Svita **late Oligocene**
Locality: Sayaken

Terrestrial vertebrates were found near the Sayaken Tomb (Mogila Sayaken). The fauna is presently studied by O. G. Bendukidze.

The lectostratotype of the Aral' Svita also occurs near the Mogila Sayaken, 17 km north of the Gulf of Tshchebas.

Fauna of the Aral' Svita at Sayaken

(all taxa cited by Bendukidze, 1977)

LAGOMORPHA

OCHOTONIDAE
— *Desmatolagus* aff. *gobiensis* Matthew & Granger, 1923d
— *Sinolagomys* aff. *kansuensis* Bohlin, 1937; cited by Bendukidze, pers. com., 1984
(= *Sinolagus* sp.; cited by Bendukidze, 1977)
— *Sinolagomys* aff. *gracilis* Bohlin, 1942; cited by Bendukidze, pers. com., 1984 (as *S.* aff. *minor*)

RODENTIA

CASTORIDAE Indet.; cited by Bendukidze, pers. com., 1984)

CRICETIDAE
— *Eucricetodon* aff. *asiaticus* (Matthew & Granger, 1923d) Lindsay, 1977
(= *Eumys* (aff.) *asiaticus* Matthew & Granger, 1923d; cited by Gabunia, pers. com., 1980)
(= *Cricetodon* aff. *deploratus* Shevyreva, 1967, *in* Lindsay, 1977)
— *Aralomys* aff. *glikmani* Vorontzov, 1963
— *Aralomys gigas* Argyropulo, 1939a

CTENODACTYLIDAE
— *Tataromys* aff. *deflexus* Teilhard de Chardin, 1926

CARNIVORA

FELIDAE Indet.
AMPHICYONIDAE? Indet. (cited as Ursidae indet.)

PERISSODACTYLA

TAPIRIDAE Indet.; cited by Bendukidze, pers. com., 1984
(= *Protapirus* sp.; cited by Bendukidze, 1977)

HYRACODONTIDAE
— *Aprotodon* sp.
— *Paraceratherium* sp.

ARTIODACTYLA

GELOCIDAE
— *Prodremotherium* sp.

Aralomys glikmani Vorontzov, 1963, was described from the Tshchebas region, at the Zharlepes well, about 3 km from the Aral Sea. The Sayaken locality is situated about 15 km inland this site.

Source : MNHN, Paris

Lat. 45° 38′ N, approx.
Long. 58° 26′ N, approx.

Fig. 3, n° 24

U.S.S.R.
KAZAKH S.S.R.
Aktyubinskaya Oblast'

Aral' Svita **late Oligocene**

Locality: Kuzhasay

Kuzhasay is another of the localities whose fauna is being studied by O. G. Bendukidze. No stratigraphic details were available.

Fauna of the Aral' Svita at Kuzhasay

LAGOMORPHA

OCHOTONIDAE — *Sinolagomys* sp.; cited by Kozhamkulova & Orlovskaya, 1971

FAMILY Indet. — "*Sciurus*" sp.; cited by Bendukidze, 1977; the same determined by Bohlin at Taben Buluk (Bendukidze, pers. com., 1984)

CASTORIDAE — *Agnotocastor* sp.; cited by Bendukidze, pers. com., 1984 (= *Propalaeocastor* sp.; cited by Bendukidze, 1977)
— *Steneofiber* sp.; cited by Kozhamkulova & Orlovskaya, 1971

CRICETIDAE — *Aralomys gigas* Argyropulo, 1939a; cited by Kozhamkulova, 1971

CTENODACTYLIDAE — *Tataromys* aff. *grangeri* Bohlin, 1946; cited by Bendukidze, pers. com., 1984
(= *Tataromys* sp.; cited by Bendukidze, 1977)

CARNIVORA

FELIDAE Indet.; cited by Bendukidze, 1977

PERISSODACTYLA

CHALICOTHERIIDAE — "*Phyllotillon*" *betpakdalensis* Flerov, 1938 was cited by Bazhanov, 1962, but Bendukidze (pers. com., 1984) claims that this form is never found in the Aral region

HYRACODONTIDAE — *Paraceratherium* sp.; cited by Bendukidze, 1977
— Hyracodontidae indet. (Indricotheriidae indet.); cited by Bazhanov, 1962

RHINOCEROTIDAE Indet., cited by Bendukidze, 1977

ARTIODACTYLA

GELOCIDAE — *Amphitragulus* sp.; cited by Bendukidze, 1977
— *Amphitragulus boulangery* Abdrakhmanova, 1973, *nomen nudum*
— *Amphitragulus* cf. *boulangeri* det. Musakulova[39]; cited by Kozhamkulova & Orlovskaya, 1971
— *Micromeryx flourensianus* Abrakhmanova, 1973, *nomen nudum*

Amphitragulids were discovered at Bestobe, 2 km southeast of Kuzhasay; cited by Kozhamkulova, 1974

39 Abdrakhmanova née Musakulova.

Source : MNHN, Paris

Lat. 45° 30′ N, approx.
Long. 58° 22′ E, approx. Fig. 3, n° 24

U.S.S.R.
KAZAKH S.S.R.
Kyzyl-Ordinskaya Oblast'

Aral' Svita **late Oligocene**
Locality: Zhilansay

This locality was discovered by O. G. Bendukidze in 1973. It is situated in a ravine 3-4 km south of the ravine containing Kuzhasay. The collections are being studied by Bendukidze.

Fauna of the Aral' Svita of Zhilensay

LAGOMORPHA
OCHOTONIDAE — *Sinolagomys* aff. *kansuensis* Bohlin, 1937; cited by Bendukidze, pers. com., 1984
(= *Sinolagomys* sp.; cited by Bendukidze, 1977)

RODENTIA
FAMILY Indet. — "*Sciurus*" sp.; cited by Bendukidze, 1977
CASTORIDAE — *Agnotocastor* sp.; cited by Bendukidze, pers. com., 1984
(= *Propalaeocastor* sp.; cited by Bendukidze, 1977)
CTENODACTYLIDAE — *Tataromys* aff. *grangeri* Bohlin, 1946; cited by Bendukidze, pers. com., 1984
— *Tataromys* sp.; cited by Bendukidze, 1977

CARNIVORA
FELIDAE Indet.; cited by Bendukidze, 1977

PERISSODACTYLA
HYRACODONTIDAE — *Paraceratherium* sp.; cited by Bendukidze, 1977
RHINOCEROTIDAE Indet.; cited by Bendukidze, 1977

ARTIODACTYLA
GELOCIDAE — *Amphitragulus* sp.; cited by Bendukidze, 1977[40]

40 The faunal list of Zhilansay was mixed with that of Kuzhasay in Bendukidze, 1977.

Source : MNHN, Paris

FIG. 221. — The Georgian S.S.R. fossil localities of Benara (B) and Vani (V). Modified from the Atlas Mira, Moscow, 1954.

Lat. 41° 40′ N, approx.
Long. 42° 50′ E, approx.

U.S.S.R.
GEORGIAN S.S.R.
Adigeni rayon

Upper Pestrotsvet Svita **late Oligocene**
Locality: Benara

The settlement of Benara is in the south Georgian region of Akhaltsikhe, near the bridge across the Abastumani-Gele River. Immediately to the north of Benara begins a series of reddish hills made up of what was termed by Gabunia (1964) the Pestrotsvet Svita[41]. Exposures of the

41 Pestrotsvet = variegated.

Source : MNHN, Paris

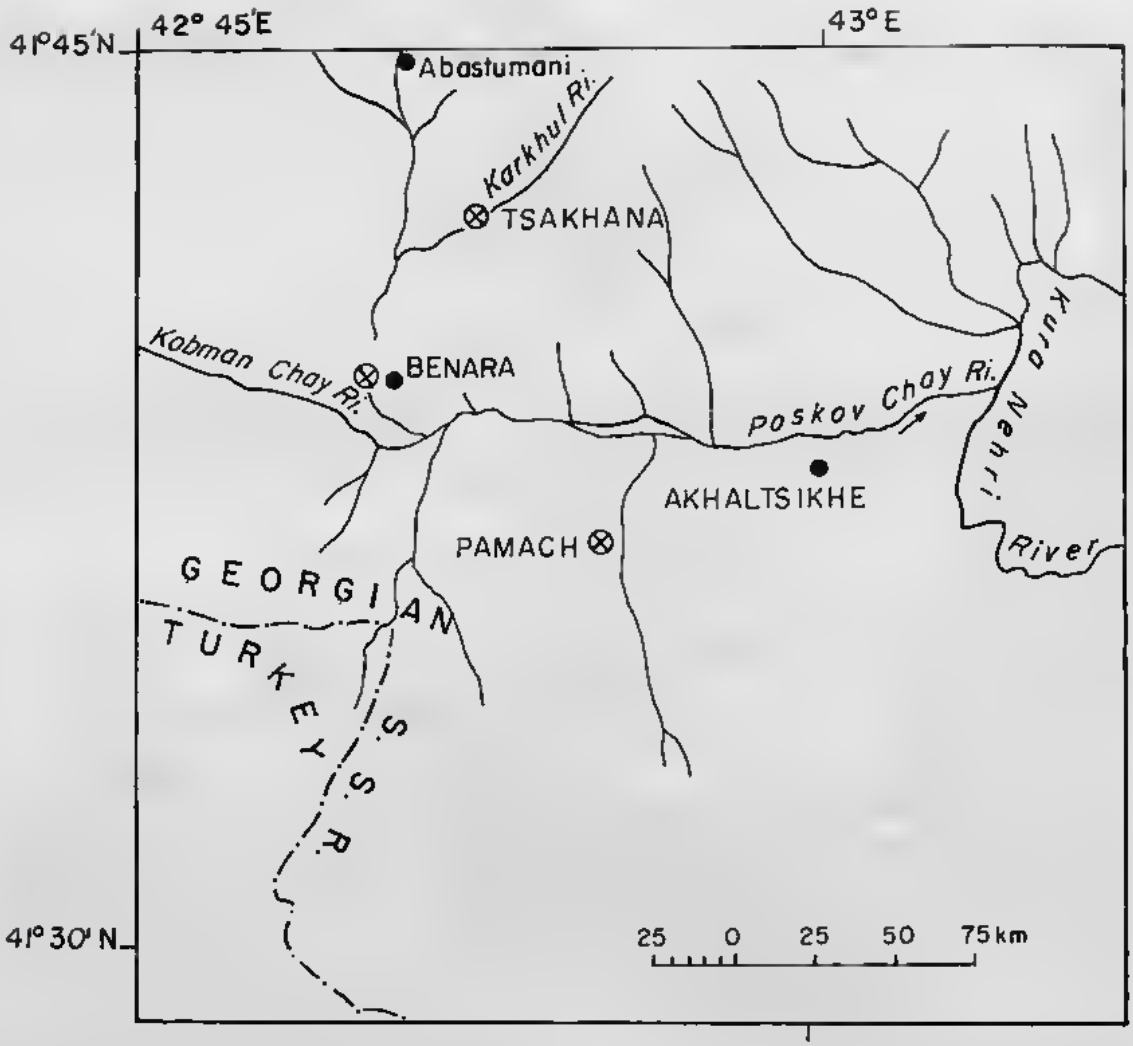


FIG. 222. — Region of Akhaltsikhe, showing the position of the localities Benara, Tsakhana and Pamach, Georgian S.S.R. Modified from a map provided by G. V. Shkurkin.

latter are widely distributed in the Akhaltsikhe Depression, in which Benara occurs. The hills are composed of an alternation of brick red, slightly calcareous plastic clays and predominantly light gray or greenish sandstones containing dissociated and fragmentary fossil vertebrates, first discovered by the geologist M. Khutshua about 1950.

The section in the Akhaltsikhe Depression has been determined as follows:

— the tick volcanogenic deposits of the Goderz Svita; middle Miocene or Pliocene age

— the Upper Pestrotsvet Svita, an alternance of reddish calcareous clays and grayish sandstones..... 170 to 500 m

— the Upper Corbula sandstone, also termed the Upper Tskhruta-Tsakhana sandstone.... ..... up to 150 m

— the Lignite Bed, unconsolidated sandstone and variegated clays containing lignite .... between 60 and 150 m

— the Lower Corbula sandstone (a greenish-yellow graywacke), also termed the Lower Tskhruta-Tsakhana sandstone. about 40 m

— the middle Oligocene Kuratuban[42] beds of argillaceous sandstone.

42 Kuratuban = fat horse.

Source : MNHN, Paris

The geologists have established that the Pestrotsvet Svita is only developed in the bottom part of the synclinal folds of the region, within the limits of the distribution of the coal-bearing svita.

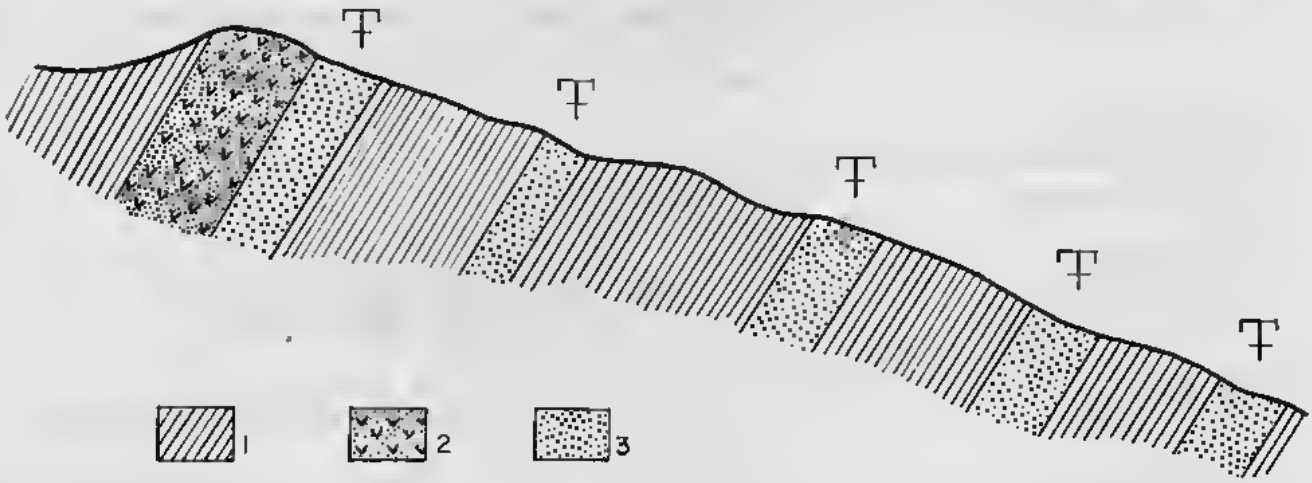


FIG. 223. — Section taken just north of the Benara school and representing an overturned syncline; Georgian S.S.R. 1. the reddish clay and greenish gray sandstone of the Lignite Bed; observable thickness, about 30 m; 2. the thin bedded, fine grained, compact quartzitic Upper Corbula sandstone; thickness, about 4 m; 3. the bone-bearing sandstone horizons of the upper Pestrotsvet Svita; total thickness of the svita, about 40 m. Modified from Gabunia, 1964.

Details of the upper Pestrotsvet Svita, which has furnished the Benara fauna, are shown in Fig. 223 and the subdivisions are as follows:

10. reddish clays ..... about 3 m
9. yellowish buff and unconsolidated sandstone, the fifth bone-bearing bed ..... about 3 m
8. "dirty" red clays ..... about 5 m
7. gray, dense, medium grained sandstone, the fourth bone-bearing bed ..... about 3 m
6. brick red clays ..... about 5 m
5. greenish gray, coarse grained, occasionally crossbedded sandstone, the third bone-bearing bed ..... about 4 m
4. reddish green clays ..... about 7 m
3. indistinctly bedded, medium grained sandstone, the second bone-bearing bed ..... about 2 m
2. brick red clays ..... about 6 m
1. coarse grained sandstone, the first bone-bearing bed ..... about 2 m

Evidence to support a late Oligocene age for the Benara fauna is given by the relationships of the overlying Goderz Svita, with its Neogene flora and *Hipparion*, and of the underlying middle Oligocene Kuratuban beds. Within the latter has been found a complex of fossil mollusks that is said to correlate well with that of the Rupelian stage in Europe. However, analysis of the Benara mammals themselves indicates an age that might be older than Miocene, as attested by such primitive elements as *Hyaenodon* and *Ardynia*; an age of late Oligocene was proposed by Gabunia (1964).

Fauna of the Pestrotsvet Svita at Benara

RODENTIA

CYLINDRODONTIDAE Indet.; cited by Gabunia, 1964

CARNIVORA

FELIDAE — *Nimravus* sp.; cited by Gabunia, 1964

AMPHICYONIDAE — *Amphicyon* sp.; cited by Gabunia, 1964

— *Cephalogale meschethense* Gabunia, 1964

Source : MNHN, Paris

MUSTELIDAE — *Plesictis* sp.; cited by Gabunia, 1964

CREODONTA

HYAENODONTIDAE — *Hyaenodon dubius* Filhol, 1873
(= *Hyaenodon aymardi* Filhol, 1882, *in* Lange-Badré, 1979); cited by Gabunia, 1964
— *Hyaenodon* sp.; cited by Gabunia, 1964

PERISSODACTYLA

BRONTOTHERIIDAE Indet.; cited by Gabunia, 1964

CHALICOTHERIIDAE — *Schizotherium chucuae* Gabunia, 1951
— *Borissiaka* sp.; cited by Flerov *et al.*, 1974

HELALETIDAE — *Colodon* sp.; cited by Gabunia, 1964

HYRACODONTIDAE — *Ardynia plicidentata* Gabunia, 1964
(= *Ardynia* sp.; *in* Radinsky, 1967)
— *Ardynia* sp., *in* Radinsky, 1967
(= *Prothyracodon* sp.; cited by Gabunia, 1964)
— *Benaratherium callistrati* Gabunia, 1955 (generic distinctness questioned by Radinsky, 1967)
— *Aceratherium* sp., cited by Gabunia, 1964

RHINOCEROTIDAE — *Eggysodon* sp.
(= *Allacerops* (= *Eggysodon in* Brunet, 1979); cited by Gabunia, 1964)

RHINOCEROTOIDEA Indet. — *Meschotherium mescheticum* Gabunia, 1964

ARTIODACTYLA

ENTELODONTIDAE — *Paraentelodon intermedium* Gabunia, 1964

ANTHRACOTHERIIDAE — *Hyoboops* sp.; cited by Gabunia, 1964
— *Bothriodon* cf. *velaunus* Pomel, 1852; cited by Gabunia, 1964
— *Bothriodon* sp., cited by Gabunia, 1964
— *Anthracotherium kwablianicum* Gabunia, 1964
— *Anthracotherium* sp.; cited by Flerov *et al.*, 1974
— *Parabrachyodus* cf. *borbonicoides* (Forster Cooper, 1924) Viret, 1961
(= *Elomeryx* cf. *borbonicoides*; cited by Gabunia, 1964)
— *Telmatodon* sp.; cited by Gabunia, 1964

GELOCIDAE — *Lophiomeryx benarensis* Gabunia, 1964
— *Prodremotherium trepidum* Gabunia, 1964

TRAGULIDAE — *Iberomeryx parvus* Gabunia, 1964

Lat. 41° 42′ N
Long. 42° 52′ E

U.S.S.R.
GEORGIAN S.S.R.
Adigeni Rayon?

Lower Tskhruta-Tsakhana Svita **late Oligocene**
(or lower Corbula sandstone)
Locality: Tsakhana

To the north of Benara, near the settlement of Tsakhana[43], a few fragmentary vertebrate fossils have been found in the lower Corbula sandstone. They were first discovered by the geologist

43 Tsakhana = tea house.

Source : MNHN, Paris

Laliyev about 1955, and the region was further examined by Gabunia in the early 1960's.

The interest of these meager remains resides in their stratigraphic position, much lower than the upper Pestrotsvet Svita in which the Benara locality occurs.

The material is really too poor to be adequately compared with the Benara fauna; the entelodont is represented by an incisor, the anthracothere by a phalanx, and *Lophiomeryx* by M1/ or M2/.

Faunal list from Tsakhana

ARTIODACTYLA

ENTELODONTIDAE Indet.; cited by Gabunia, 1964

ANTHRACOTHERIIDAE Indet.; cited by Gabunia, 1964

GELOCIDAE — *Lophiomeryx* sp.; cited by Gabunia, 1964

Lat. 41° 38′ N
Long. 42° 55′ E, approx.

U.S.S.R.
GEORGIAN S.S.R.
Adigeni Rayon

Lignite Bed **late Oligocene**

Locality: Pamach

In 1979 a few mammalian remains were discovered in the Lignite Bed, situated between the upper and the lower Corbula sandstones, at Pamach. So far, only two teeth of a large anthracothere have been collected. These suggest, however, an age similar to that of Benara for the sediments and, with the vertebrates known from the upper Pestrotsvet Svita at the latter site, in addition to those from the lower Corbula sandstone at Tsakhana, indicate a potentially fossiliferous sequence in the Akhaltsikhe Depression.

Fauna of the Lignite Bed at Pamach

ARTIODACTYLA

ANTHRACOTHERIIDAE — *Anthracotherium* cf. *kwablianicum* Gabunia, 1964; cited by Gabunia, pers. com., 1981

Source : MNHN, Paris

LATE OLIGOCENE

Composite List

(**Agp**: Agyspe; **Ak**: Aktau; **Ask**: Askasan-Sor; **Ben**: Benera; **Ber**: Bermoti; **Bwn**: Junggar "brown" fm.; **Ik**: Ikeno; **Kuz**: Kuzhasay; **Nr**: Nura; **Pam**: Pamach; **Pegu**: Pegu; **Say**: Sayaken; **Shg**: Shargaltein Gol; **Sos**: Sary-Ozek Station; **Sry**: Saroy; **Tb**: Taben Buluk; **Tkn**: Tsakhana; **Tsy**: Taoshuyuanzi; **Yik**: Yikebulage; **Zln**: Zhilansay)

INSECTIVORA

ERINACEIDAE

Agp — *Palaeoscaptor acridens*
Shg — *Palaeoscaptor* cf. *acridens*
Shg, Yik — *Amphechinus* sp.
Tb, Yik, Tsy — *Amphechinus* cf. *rectus*
Tsy — *Amphechinus*? sp.
Yik, Tb — *Amphechinus minimus*
Shg — Erinaceidae indet.
Tb — Erinaceidae? indet.

Tb SORICIDAE indet.

Tb TALPIDAE? indet.

Nr INSECTIVORA indet.

LAGOMORPHA

OCHOTONIDAE

Agp, Say — *Desmatolagus* aff. *gobiensis*
Shg — *Desmatolagus shargaltensis*
Shg — *Desmatolagus parvidens*
Shg, Yik, Tb — *Desmatolagus* sp.
Shg, Yik, Tsy, Tb — *Sinolagomys kansuensis*
Zln, Say — *Sinolagomys* aff. *kansuensis*
Shg, Tb, Yik — *Sinolagomys major*
Shg, Yik — *Sinolagomys gracilis*
Say — *Sinolagomys* aff. *gracilis*
Yik, Kuz — *Sinolagomys* sp.

Yik Lagomorpha indet.

RODENTIA

SCIURIDAE?

Zln, Tb, Kuz — "*Sciurus*" sp.
Shg — Sciuridae indet.

TSAGANOMYIDAE

Shg — *Tsaganomys altaicus*
Yik — *Tsaganomys* sp.

Ben CYLINDRODONTIDAE indet.

CASTORIDAE

Agp, Kuz — *Steneofiber* sp.
Zln, Agp, Kuz — *Agnotocastor* sp.
Agp, Say — "*Propalaeocastor*" *kumbulakensis*
Nr, Yik, Say — Castoridae indet.

CRICETIDAE

Agp — *Eucricetodon* aff. *caducus*
Agp, Say — *Eucricetodon* aff. *asiaticus*
Tb — *Eucricetodon* sp.
Say, Agp, Kuz — *Aralomys gigas*

Source : MNHN, Paris

Say — *Aralomys* aff. *glickmani*
Agp — *Eumysodon orlovi*
Agp — *Eumysodon spurius*
Agp — *Argyromys aralensis*
Agp — *Argyromys woodi*
Agp — *Protolactaga borissiaki*

TACHYORYCTOIDIDAE

Shg, Yik — *Tachyoryctoides obrutschewi*
Tb — *Tachyoryctoides* cf. *obrutschewi*
Shg — *Tachyoryctoides intermedius*
Shg — *Tachyoryctoides pachygnathus*
Yik — *Tachyoryctoides kokonorensis*
Tb — *Tachyoryctoides* sp.
Tb — Tachyoryctoididae indet.

Nr RHYZOMYIDAE indet.

CTENODACTYLIDAE

Shg, Tb, Yik — *Tataromys* cf. *plicidens*
Zln — *Tataromys* sp.
Yik — *Tataromys deflexus*
Say — *Tataromys* aff. *deflexus*
Tb — *Tataromys sigmodon*
Yik, Tsy — *Tataromys* cf. *sigmodon*
Tb — *Tataromys grangeri*
Kln, Yik, Kuz — *Tataromys* cf. *grangeri*
Yik — *Tataromys suni*
Shg — cf. *Tataromys* sp.
Shg — *Leptotataromys gracilidens*
Shg — *Karakoromys* cf. *decessus*
Shg — cf. *Karakoromys* sp.
Tb — *Yindirtemys woodi*

DIPOPIDAE

Yik, Tb — *Parasminthus parvulus*
Yik, Tb — *Parasminthus tangingoli*
Tb — *Parasminthus asiaecentralis*
Shg, Tb — Sicistinae indet.

Ask Rodentia indet.

CARNIVORA

FELIDAE

Ben — *Nimravus* sp.
Zln, Kuz, Agp, Say — Felidae indet.
Ask — Machairodontinae indet.

AMPHICYONIDAE

Ben — *Cephalogale meschethense*
Ben — *Amphicyon* sp.
Ask — Amphicyoninae indet.
Say — Amphicyonidae? indet.

MUSTELIDAE

Ben — *Plesictis* sp.

Shg, Tb, Ask Carnivora indet.

CREODONTA

HYAENODONTIDAE

Sry, Ben — *Hyaenodon* sp.
Ben — *Hyaenodon dubius*
Tsy — *Hyaenodon*? sp.

Source : MNHN, Paris

PERISSODACTYLA

Ben BRONTOTHERIIDAE indet.

CHALICOTHERIIDAE

Ben — *Schizotherium chucuae*
Tsy, Ak — *Schizotherium* sp.
Tb — *Schizotherium*? sp.
Ask, Sry, Kuz — *Borissiakia betpakdalensis*
Ben — *Borissiakia* sp.

HELALETIDAE

Ben — *Colodon* sp.

Say TAPIRIDAE indet.

HYRACODONTIDAE

Agp, Ask — *Aprotodon borissiaki*
Say — *Aprotodon* sp.
Agp — *Aceratherium aralense*
Ben, Tb — *Aceratherium*
Tsy — *Aceratherium* sp.
Agp, Sos — *Paraceratherium prohorovi*
Tsy — *Paraceratherium tienshanensis*
Tsy — *Paraceratherium lipidus*
Zln, Kuz, Say, Zln, Ak — *Paraceratherium* sp.
Agp — *Protaceratherium* sp.
Ben — *Benaratherium callistrati*
Shg, Sry — *Indricotherium* sp.
Ask — *Indricotherium* or *Paraceratherium* sp.
Ben — *Ardynia plicidentata*
Ben — *Ardynia* sp.
Bwn — *Dzungariotherium orgosensis*
Tsy — *Dzungariotherium turfanensis*
Kuz — Hyracodontidae indet.

RHINOCEROTIDAE

Agp, Ben — *Eggysodon* sp.
Ask — *Brachypotherium* sp.
Ask — *Dicerorhinus minutus*
Kuz, Zln, Tb, Ak — Rhinocerotidae indet.

RHINOCEROTOIDEA indet.

Ben — *Meschotherium meschethicum*

AMYNODONTIDAE

Pegu — *Cadurcotherium* sp.

ARTIODACTYLA

ENTELODONTIDAE

Sos — *Neoentelodon dzhungaricus*
Ben — *Paraentelodon intermedium*
Sry, Tkn — Entelodontidae indet.

ANTHRACOTHERIIDAE

Ask — *Hemimeryx turgaicus*
Ben — *Anthracotherium kwablianicum*
Pam — *Anthracotherium* cf. *kwablianicum*
Ask, Ben — *Anthracotherium* sp.
Ben — *Hyoboops* sp.
Ben — *Bothriodon* cf. *velaunus*
Ben — *Bothriodon* sp.
Ben — *Parabrachyodus* cf. *borbonicoides*
Ben — *Telmatodon* sp.

Source : MNHN, Paris

Ik — "*Brachyodus*" *japonicus*
Sri, Tkn — Anthracotheriidae indet.

CERVIDAE

Tb — *Eumeryx* sp.
Shg — *Eumeryx*? sp.
Shg — Cervulinae? indet.

SUIDAE

Ask — *Conohyus betpakdalensis*

GELOCIDAE

Ask — *Lophiomeryx turgaicus*
Ben — *Lophiomeryx benarensis*
Agp, Tkn, Bwn — *Lophiomeryx* sp.
Ben — *Prodremotherium trepidum*
Ak — *Prodremotherium flerowi*
Agp, Ask, Say — *Prodremotherium* sp.
Agp — *Miomeryx* sp.
Agp, Kuz, Zln — *Amphitragulus* sp.

TRAGULIDAE

Ben — *Iberomeryx parvus*
Shg BOVIDAE indet.

SIRENIA

DUGONGIDAE

Ber — *Halitherium* sp.

ORDER indet.

DIDYMOCONIDAE

Tsy — *Didymoconus berkeyi*
Shg, Tb — *Didymoconus* sp.
Tb — aff. *Didymoconus*? sp.

Source : MNHN, Paris

Source : MNHN, Paris

CONCLUSIONS

As indicated in the introduction, the correlating of the faunal assemblages presented here has been one of our major preoccupations. Whether or not time and further research will confirm our decisions, we will cite below the reasons that have inspired them.

Given the frequently found expression of regret in the literature as to the exclusively terrestrial nature of the Paleogene sediments of China, Mongolia and much of the Soviet Union, and the consequent lack of correlation with the marine biostratigraphic scales, it is somewhat surprising to find that, really, the faunas of the Far East can be fixed rather securely at a number of levels, by taxa shared with the better known sequences in Europe and North America.

Unfortunately, it is not with the Paleocene faunas that intercontinental correlation can be well demonstrated. The middle Paleocene of China (there are no other candidates) is characterized by the presence of bemalambdids. While these forms typify a group of faunas that are probably of middle Paleocene age, there is no supporting data from common taxa in other regions of the world.

In examining the total spectrum of faunules from the various formations we have placed in the late Paleocene one is struck by the distinction of two groups. One of them is typified by the presence of *Archaeolambda* and primitive members of the pastoralodontid pantodonts, phenacolophids and arctostylopids. It includes mammals from the Doumu, Shuangtasi, Nongshan and Chijiang Formations. The other is a rather homogeneous assemblage formed by the mammals from Nomogen, Bayn Ulan, Gashato and the lower part (Naran and Zhigden Members) of the Naran-Bulak Svita, both in the Nemegt and Bugin-Tsav Basins. The Bayn Ulan fauna heralds the early Eocene with a few indications of arriving perissodactyls and, at the lower limit of the upper group, the Taizicun mammals constitute a sort of connecting link between the earlier late Paleocene and those of the terminal Paleocene. The two groups are furthermore united by the common presence of *Archaeolambda, Pastoralodon, Prodinoceras* and *Pseudictops*; the phenacolophids, *Yuelophus* and *Tienshanilophus*, are probably referable to the Gashato genus *Phenacolophus* and constitute another common element.

The pre-perissodactyl faunas of China and Mongolia do not offer the strongest evidence for confirming their age by intercontinental correlation. However, three genera, *Coryphodon, Prodinoceras* and *Arctostylops*, are shared with North America in beds that range in age from the late Paleocene through the early Eocene. In contrast to their distribution in Asia, where only *Coryphodon* continues to thrive, all three also flourish during the early Eocene of North America. Their first appearance is taken here to be significant. In China and Mongolia these genera stratigraphically precede faunas of a typical basal Eocene character (see below); in North America they do the same, occurring in late Paleocene beds. There would seem to be little valid argument for regarding their first appearance in Asia as differing greatly in age from that in North America. Mammalian dispersal, as noted by Rose (1981), can occur so rapidly as to be unresolvable in geochronological terms. It is reasonable to assume that the faunas of Nomogen, Gashato and the lower part of the Naran-Bulak Svita are late Paleocene, on the North American scale.

The appearance of *Homogalax, Heptodon, Propachynolophus, Hyracotherium, Hyopsodus*, the omomyid primate *Altanius* and an undescribed artiodactyl can be taken as announcing the early Eocene. These forms are accompanied by an important number of insectivores that are noteworthy because of their Holarctic, not endemic, nature, by many ctenodactylid rodents (but which probably evolved in Asia from mixodonts), by large mixodonts such as *Rhombomylus, Matutinia* and *Gomphos* and, as in North America, the continued presence of *Coryphodon*. This distinctly Eocene fauna is firmly established

Source : MNHN, Paris

by collections from the Zhangshanji, Yuhuangding, Limuping, Xinyu, Wutu, Niushan, Dabu, Shisanjianfang Formations and the top part (Bumban Member) of the Naran-Bulak Svita.

The early Eocene Wasatchian and Ypresian Stages can be considered to represent approximately equivalent time intervals. In Europe, this interval is firmly linked to marine phenomena (rocks, floras and faunas; see Vinken, R., Results of the International Geological Correlation Program Project 124, in press). The continental faunas of Tsagan-Khushu (Mongolia), of Changle and Linqu (Shandong), and of the Turpan Basin (Xinjiang) represent parts of the same interval.

The base of the European middle Eocene Lutetian Stage and that of the Bridgerian are essentially time-stratigraphically equivalent. In duration, however, the Bridgerian Stage was considerably the shorter, lasting only about 2 million years. The Friars Formation of southern California has yielded terrestrial mammals of an Uintan aspect (Golz & Lillegraven, 1977), but the formation can be correlated with the marine Ardath Shales that are accepted as middle Eocene in age. This incidentally supports a middle Eocene equivalence for (at least) the lower part of the Uintan Stage. In the state of Mississippi a brontothere was discovered (Gazin & Sullivan, 1942) whose age was younger, according to current concepts (being similar to late Uintan relatives and more evolved than Bridgerian ones), than that attributed to the marine Lisbon Formation (middle Eocene) from which it came. This also implies that a considerable portion of the Uintan Stage is equal to the marine middle Eocene.

In contrast to the paelontologically rich Bridgerian Stage the Lutetian in France has furnished various isolated finds of continental mammals and a small fauna at La Défense, near Paris (Ginsburg *et al.*, 1977). Until rather recently only the Lutetian was regarded as middle Eocene, but Berggren *et al.* (1978) proposed the placement of the middle-late Eocene boundary between the overlying Bartonian and the Priabonian Stages. This decision was based on the demonstration by Cavelier (1979) and Cavelier and Pomerol (1976) that the Bartonian is older than, not time-equivalent to, the Priabonian, as had previously been thought. Rather than increase the extent of the late Eocene, Berggren *et al.* opted for an expanded middle Eocene. The Bartonian mammalian faunas integrated into the marine biostratigraphic scale correspond to the NP 16 and NP 17 calcareous nannoplankton zones, which areessentially equivalent to the planktonic foraminiferal zones P 13 and P 14. With the lower part of the Uintan probably correlating with the Lutetian, an even larger part should correlate with the Bartonian. As the Uintan has an exceptionally long duration (8-9 M.Y.) it is not inconceivable that its upper horizon is still contemporary with accepted late Eocene continental and marine sediments. This returns us to the problem in hand, namely the correlation of Asian mammalian faunas.

Chinese paleontologists have to a certain extent regarded the Guanzhuang fauna from Xintai (Shandong) as their basic reference assemblage for the middle Eocene. This is supported by the presence in common with the North American Bridgerian, of *Palaeosyops, Hyrachyus* and *Helaletes*. The presence of other Bridgerian or early Uintan taxa in Chinese faunas prompted us to undertake an analysis of these assemblages with the aim of determining how firm a correlation really exists. A corollary of this problem, in view of the recently expanded middle Eocene in the Occident, is the question of what age they should be assigned to.

To begin this analysis we chose the large and relatively well documented faunas of Inner Mongolia, closer by geography and climate to those of North America than the southern Asian assemblages. A distinct difference in faunal constituents between the Irdin Manha (and Ulan Shireh) and Shara Murun is immediately apparent; extremely few taxa are common to both.

We took this convenient distinction to indicate a clear difference in age. The earlier faunal assemblage, that of Irdin Manha, displays a significant number of elements in common with that of the middle Eocene of North America, while the younger Shara Murun fauna shares few genera and no species. A closer look led us to suspect that the Irdin Manha could indeed represent a time interval equivalent at least to part of the North American middle Eocene.

To illustrate the considerable difference in faunal composition that separates the Irdin Manha from the Shara Murun assemblage, the latter are presented in a comparative table below.

Source : MNHN, Paris

		IRDIN MANHA FM	SHARA MURUN FM
(IR = Irdin Manha; UL = Ulan Shireh; HBL = Huhebolhe)			
	PROTEUTHERIA		
IR	Pantolestidae	Indet.	
	PANTODONTA		
IR, UL	Coryphodontidae	— *Eudinoceras mongoliensis*	
UL	Pantolambdodontidae	— *Pantolambdodon inermis*	
HBL		— Pantodonta indet.	
	LAGOMORPHA		
UL	Leporidae	— *Shamolagus grangeri*	— *Shamolagus medius*
UL		— Palaeolaginae indet.	— *Gobiolagus tolmachovi*
	Ochotonidae		— *Desmatolagus* sp.
	RODENTIA		
IR, HBL	Paramyidae	Indet.	
HBL	Ctenodactylidae	— *Advenimus burkei*	
UL		— *Advenimus bohlini*	
UL		— cf. *Advenimus* sp.	
UL		— *Yuomys weijingensis*	— *Yuomys cavioides*
	CARNIVORA		
IR	Miacidae	— *Miacis invictus*	
UL		— Miacidae indet.	
UL	Canidae	— cf. "*Cynodictis*" sp.	
	CREODONTA		
UL	Oxyaenidae	— *Sarkastodon mongoliensis*	
IR	Hyaenodontidae	— *Propterodon morrisi*	
UL		— cf. *Propterodon morrisi*	— cf. *Propterodon morrisi*
			— "*Pterodon*" *hyaenoides*
	CONDYLARTHRA		
IR, HBL	Arctocyonidae	— *Andrewsarchus mongoliensis*	
IR	Mesonychidae	— *Hapalodectes serus*	— "*Olsenia mira*"
UL		— *Hapalodectes serus*?	
IR, UL		— cf. *Mesonyx* sp.	
UL		— *Harpagolestes*? *orientalis*	
IR		— cf. *Pachyaena* sp.	
HBL		— *Mongolonyx dolichognathus*	
IR, UL		— Mesonychidae indet.	
	PERISSODACTYLA		
IR	Brontotheriidae	— *Metatelmatherium parvum*	— *Telmatherium*? sp.
HBL		— *Metatelmatherium cristatum*	— *Manteoceras*? sp.
IR, UL		— *Microtitan mongoliensis*	— *Rhinotitan kaiseni*
IR		— *Gnathotitan berkeyi*	— *Rhinotitan mongoliensis*
HBL		— *Protitan minor*	— *Rhinotitan andrewsi*
UL		— *Protitan bellus*	— *Pachytitan ajax*
IR		— *Protitan obliquidens*	— *Titanodectes minor*
IR		— *Protitan grangeri*	— *Titanodectes ingens*

Source : MNHN, Paris

HBL		— *Protitan*? *cingulatus*	
UL		— *Desmatotitan tukhumensis*	
UL		— *Acrotitan ulanshirehensis*	
IR		— *Epimanteoceras robustus*	
UL		— *Epimanteoceras formosus*	
UL		— *Dolichorhinoides angustidens*	
HBL	EOMOROPIDAE	— *Litolophus gobiensis*	
	CHALICOTHERIIDAE		— *Schizotherium* sp.
IR	DEPERETELLIDAE	— *Teleolophus medius*	— *Teleolophus medius*?
HBL		— cf. *Teleolophus medius*	
UL		— *Teleolophus medius*?	
			— *Deperetella cristata*
IR	HELALETIDAE	— *Helaletes mongoliensis*	
HBL		— *Helaletes fissus*	
HBL		— *Helaletes fissus*?	
HBL		— *Helaletes* sp.	
HBL		— cf. *Hyrachyus* sp.	
IR, HBL	LOPHIALETIDAE	— *Lophialetes expeditus*	
UL		— *Lophialetes expeditus*?	
UL		— *Lophialetes* sp.	— *Lophialetes* sp. (stratigraphic position uncertain)
IR		— *Lophialetes*? sp.	
IR, UL		— *Breviodon minutus*	
UL, HBL		— *Breviodon*? sp.	
IR		— *Simplaletes sujiensis*	
UL		— *Simplaletes ulanshirehensis*	
UL		— *Schlosseria* cf. *magister*	
HBL		— cf. *Schlosseria magister*	
UL		— *Zhongjianoletes chowi*	
UL		— *Zhongjianoletes*? sp.	
IR, UL	LOPHIALETIDAE?	— *Rhodopagus pygmaeus*	— *Rhodopagus minimus*
IR, UL	HYRACODONTIDAE	— *Triplopus*? *proficiens*	
			— *Triplopus? progressus*
			— *Juxia borissiaki*
HBL		— *Forstercooperia grandis*	
UL		— *Forstercooperia* cf. *grandis*	
IR		— *Forstercooperia totadentata*	
IR	AMYNODONTIDAE	— *Lushiamynodon sharamurenensis*	— *Lushiamynodon sharamurenensis*
HBL		— *Rostriamynodon grangeri*	— *Sharamynodon mongoliensis*
			— *Caenolophus obliquus*
			— *Caenolophus promissus*
			— *Sianodon ulausuensis*
			— *Sianodon* sp.
			— *Gigantamynodon promissus*
			— cf. *Cadurcodon* sp.
	ARTIODACTYLA		
	ANTHRACOTHERIIDAE		— *Ulausuodon parvus*
			— cf. *Anthracokeryx* sp.
IR	LEPTOMERYCIDAE	— cf. *Archaeomeryx* sp.	— *Archaeomeryx optatus*
IR, UL	HELOHYIDAE	— *Gobiohyus orientalis*	
IR		— *Gobiohyus pressidens*	
IR		— *Gobiohyus robustus*	
	ORDER INDET.		
IR	DIDYMOCONIDAE	— *Mongoloryctes acutus*	
UL	DIDYMOCONIDAE?	— *Kennatherium shirensis*	

Source : MNHN, Paris

Two of the pitfalls that are inherent in any quest for faunal correlation are the reliability of the published taxonomic identifications, and the possible effects of evolutionary rates. An example of the latter is the apparent near specific identity (according to Granger & Gregory, 1943) of "*Telmatherium*" *ultimum* (North America, Uinta C) and *Metatelmatherium cristatum* (Irdin Manha). Is "*T.*" *ultimum* a non-progressive migrant from Asia to North America, that is, a member of the Irdin Manha fauna still present in the late Eocene Uinta C level? Or does the resemblance mean that the Irdin Manha fauna, contrary to predominant evidence from other members of the assemblage, is really contemporaneous in part with the Uinta C?

A middle Eocene attribution is supported by the similarity of the Irdin Manha *Triplopus*? *proficiens* to the North American *T. implicatus* from the Washakie B level (middle Eocene); by the apparent identity of *Forstercooperia grandis* in both the Irdin Manha and the Washakie B/Uinta A level (middle Eocene); by the close relationship existting between *Proritan grangeri* and *Epimanteoceras formosus* of Irdin Manha and the Bridgerian *Telmatherium cultridens* and *Mantoeceras manteoceras*, and by the "more or less annectent characters" of *Desmatotitan* (Irdin Manha) between *Metatelmatherium cristatum* (Irdin Manha) and *Telmatherium cultridens* (Bridger).

Helaletes is known only from the Bridger beds in North America and is a dominant member of the Irdin Manha assemblage. Radinsky (1965) noted thet *H. mongoliensis*, is more evolved than the North American species and is morphologically not far from primitives species of *Colodon*. But even if its intermediate character suggests an intermediate age, this age would be early Uintan and still referable to the middle Eocene. In any case, *Colodon* may have appeared earlier in Asia as it is cited in the Lushi fauna.

Based on evidence, then, from the perissodactyls, there is reason to believe that a terrestrial (filter) passage existed between North America and Mongolia in the middle Eocene. According to Granger & Gregory (1943), Bridgerian and early Uintan btontotheres testify to an invasion of the Irdin Manha assemblage, but those of the succeeding Shara Murun fauna were indigenous and derived from Irdin antecedents. Wall (1980) concurs with the above in noting that based on amynodont evolution, the Arshanto (here correlated with the Irdin Manha) could correlate with the Bridger.

Other groups are not so clearly indicative of a middle Eocene exchange. The single molar representing the carnivore *Miacis* is said to resemble Bridgerian, Washakie and Uintan species and to fit into the typical concept of the genus as it is known in North America; it could therefore also suggest exchange during the middle Eocene.

Finally, very little in the Irdin Manha assemblage contradicts a middle Eocene age for it and there is considerable reason to support this attribution. We would therefore refer only the Shara Murun assemblage to the late Eocene; the Irdin Manha (and Ulan Shireh) mammals are probably best attributed to the present view of the middle Eocene. This would correspond to the Bridgerian and the early part of the Uintan in North America and to the Lutetian and Bartonian in Europe. Since it is apparent that exchange did take place during the middle Eocene, and since it is well known that terrestrial mammals are noteworthy for their relatively and actually restricted geochronologic range, as well as the rapidity of their dispersal, we see no reason to ignore these factors. Refinement has occurred in geochronology on a world wide scale; we feel that it is no longer true that the Irdin Manha and its faunal correlates in Asia represent the "early part" of the late Eocene.

Following analysis of the Irdin Manha and Shara Murun faunas of Nei Mongol, we next sought in different regions other large and varied assemblages that could be considered without doubt as contemporaneous with one or the other and which would expand the basic faunal list for the two epochs. Our choice was the Lushi fauna as correlative with the Irdin Manha and the Heti as equivalent to the Shara Murun. The lists, then, forming the nucleus of what we regard as representative of the middle and late Eocene in Asia are given below.

Source : MNHN, Paris

IRDIN MANHA AND LUSHI FAUNAS		SHARA MURUN AND HETI FAUNAS	

(IR = Irdin Manha; Lu = Lushi; HBL = Huhebolhe; UL = Ulan Shireh; Sh = Shara Murun; Het = Heti)

TAENIODONTA			
STYLINODONTIDAE			
Lu	— *Stylinodon*? sp.		
PROTEUTHERIA			
IR	— Pantolestidae indet.		
	— Insectivora *incertae sedis*	Het	— *Ictopidium lechei*
PRIMATES			
FAMILY uncertain			
Lu	— *Lushius qinlinensis*	Het	— *Hoanghonius stehlini*
PANTODONTA			
CORYPHODONTIDAE			
IR, UL	— *Eudinoceras mongoliensis*		
Lu	— *Eudinoceras* sp.		
PANTOLAMBDODONTIDAE			
UL	— *Pantolambdodon inermis*		
HBL	— Pantodonta indet.		
TILLODONTIA			
TILLOTHERIIDAE		Het	— *Adapidium huanghoensis*
DINOCERATA			
UINTATHERIIDAE			
Lu	— *Uintatherium insperatus*		
LAGOMORPHA			
LEPORIDAE			
UL	— *Shamolagus grangeri*	Sh	— *Shamolagus medius*
Lu	— *Lushilagus lohoensis*	Sh	— *Gobiolagus tolmachovi*
UL	— Palaeolaginae indet.		
OCHOTONIDAE		Sh	— *Desmatolagus* sp.
RODENTIA			
IR, HBL	— Paramyidae indet.		
CTENODACTYLIDAE			
HBL	— *Advenimus burkei*		
UL	— *Advenimus bohlini*		
UL	— cf. *Advenimus* sp.		
Lu	— *Tsinlingomys youngi*		
UL	— *Yuomys weijingensis*	Het, Sh	— *Yuomys cavioides*
CTENODACTYLIDAE indet.		Het	
CRICETIDAE		Het	— "*Cricetodon*" *schaubi*
DIPODIDAE		Het	— *Parasminthus* sp.
CARNIVORA			
MIACIDAE			
IR	— *Miacis invictus*		
Lu	— *Miacis lushiensis*		
UL	— Miacidae indet.		
CANIDAE			
Lu	— *Cynodictis* sp.	Het	— *Chailicyon crassidens*
UL	— cf. "*Cynodictus*" sp.		

Source : MNHN, Paris

FELIDAE

Lu — cf. *Eusmilus* sp.

CREODONTA

OXYAENIDAE

UL — *Sarkastodon mongoliensis*

HYAENODONTIDAE

IR, Lu — *Propterodon morrisi*
UL — cf. *Propterodon morrisi*
Lu — *Hyaenodon* sp.
Sh — cf. *Propterodon morrisi*
Het — *Hyaenodon yuanchuensis*
Het — *Pterodon* cf. *dahkoensis*
Sh — "*Pterodon*" *hyaenoides*

CONDYLARTHRA

ARCTOCYONIDAE

IR, HBL, Lu — *Andrewsarchus mongoliensis*
Lu — *Paratriisodon henanensis*

MESONYCHIDAE

IR — *Hapalodectes serus*
UL — *Hapalodectes serus*?
Sh — "*Olsenia mira*"
UL, IR — cf. *Mesonyx* sp.
UL — *Harpagolestes*? *orientalis*
IR — cf. *Pachyaena* sp.
HBL — *Mongolonyx dolichognathus*
Lu — *Honanodon hebetis*
Het — *Honanodon hebetis*
Lu — *Honanodon macrodontus*
Lu — *Lohoodon lushiensis*
IR, UL, Lu — Mesonychidae indet.

PERISSODACTYLA

BRONTOTHERIIDAE

IR — *Metatelmatherium parvum*
HBL — *Metatelmatherium cristatum*
IR, UL — *Microtitan mongoliensis*
Lu — *Microtitan*? sp.
IR — *Gnathotitan berkeyi*
HBL — *Protitan minor*
UL — *Protitan bellus*
IR — *Protitan obliquidens*
IR, Lu — *Protitan grangeri*
HBL — *Protitan? cingulatus*
UL — *Desmatotitan tukhumensis*
UL — *Acrotitan ulanshirehensis*
UL — *Epimanteoceras formosus*
IR — *Epimanteoceras robustus*
UL — *Dolichorhinoides angustidens*
Sh — *Telmatherium*? sp.
Sh — *Manteoceras*? sp.
Sh — *Rhinotitan kaiseni*
Het, Sh — *Rhinotitan mongoliensis*
Sh — *Rhinotitan andrewsi*
Sh — *Pachytitan ajax*
Sh — *Titanodectes minor*
Sh — *Titanodectes ingens*

EOMOROPIDAE

Lu — *Eomoropus* sp.
Het — *Eomoropus quadridentatus*
HBL — *Litolophus gobiensis*
Het — *Litolophus major*

Source : MNHN, Paris

	CHALICOTHERIIDAE		— *Schizotherium*
	CHALICOTHERIIDAE?		
Lu	— *Lunania youngi*		
	ISECTOLOPHIDAE Indet.	**Het**	
	DEPERETELLIDAE		
IR	— *Teleolophus medius*	**Sh**	— *Teleolophus medius*?
HBL	— cf. *Teleolophus medius*		
UL	— *Teleolophus medius*?		
Lu	— *Deperetella* sp.	**Sh**	— *Deperetella cristatum*
		Het	— *Deperetella depereti*
		Het	— *Diplolophodon similis*
	HELALETIDAE		
IR	— *Helaletes mongoliensis*		
HBL	— *Helaletes fissus*		
HBL	— *Helaletes fissus*?		
HBL	— *Helaletes* sp.		
HBL	— cf. *Hyrachyus* sp.		
Lu	— *Colodon* sp.		
	LOPHIALETIDAE		
IR, HBL	— *Lophialetes expeditus*		
UL	— *Lophialetes expeditus*?		
UL, Lu	— *Lophialetes* sp.	**Sh**	— *Lophialetes* sp. (strat. posit. uncertain)
IR	— *Lophialetes*? sp.		
IR, UL, Lu	— *Breviodon minutus*		
Lu	— *Breviodon* sp.		
UL, HBL	— *Breviodon*? sp.		
IR	— *Simplaletes sujiensis*		
UL	— *Simplaletes ulanshirehensis*		
UL	— *Schlosseria* cf. *magister*		
HBL	— cf. *Schlosseria magister*		
UL	— *Zhongjianoletes chowi*		
UL	— *Zhongjianoletes*? sp.		
	LOPHIALETIDAE?		
IR, UL	— *Rhodopagus pygmaeus*	**Sh**	— *Rhodopagus minimus*
		Het	— *Rhodopagus*? sp.
	HYRACODONTIDAE		
IR, UL	— *Triplopus*? *proficiens*	**Sh**	— *Triplopus*? *progressus*
		Sh	— *Juxia borissiaki*
HBL	— *Forstercooperia grandis*		
UL	— *Forstercooperia* cf. *grandis*		
IR	— *Forstercooperia totadentata*		
Lu	— *Forstercooperia* sp.		
Lu	— *Prohyracodon* sp.	**Het**	— *Prohyracodon* cf. *meridionale*
	AMYNODONTIDAE		
UL	— *Lushiamynodon sharamurenensis*	**Sh**	— *Lushiamynodon sharamurenensis*
Lu	— *Lushiamynodon menchiapuensis*	**Sh, Het**	— *Sharamynodon mongoliensis*
		Het	— *Sharamynodon mongoliensis*?
		Sh	— *Caenolophus obliquus*
		Sh	— *Caenolophus promissus*
Lu	— *Caenolophus* sp.	**Het**	— *Caenolophus* cf. *promissus*
		Sh	— *Sianodon ulausuensis*
		Het	— *Sianodon sinensis*
Lu	— *Sianodon honanensis*	**Het**	— *Sianodon mienchiensis*
HBL	— *Rostriamynodon grangeri*		

Source : MNHN, Paris

		Sh	— *Sianodon* sp.
		Sh	— *Gigantamynodon promissus*
		Sh	— cf. *Cadurcodon* sp.
		Het	— *Amynodon* sp.
		Het	— *Amynodon*? sp.
ARTIODACTYLA			
	DICHOBUNIDAE		
Lu	— *Dichobune* sp.	**Het**	— *Dichobune*? sp.
	ANTHRACOTHERIIDAE		
Lu	— *Anthracotherium*? sp.	**Sh**	— *Ulausuodon parvus*
		Het	— *Anthracokeryx dawsoni*
		Het	— *Anthracokeryx sinensis*
		Het	— *Anthracokeryx* cf. *sinensis*
		Sh	— cf. *Anthracokeryx* sp.
		Het	— *Anthracothema minima*
		Het	— *Anthracosenex ambiguus*
	LEPTOMERYCIDAE		
IR	— cf. *Archaeomeryx* sp.	**Sh**	— *Archaeomeryx optatus*
	HELOHYIDAE		
IR, UL, Lu	— *Gobiohyus orientalis*		
IR	— *Gobiohyus pressidens*		
IR, Lu	— *Gobiohyus robustus*	**Het**	— *Indohyus*? *yuanchuensis*
Lu	— *Gobiohyus* sp.		
ORDER INDET.			
	DIDYMOCONIDAE		
IR	— *Mongoloryctes acutus*		
	DIDYMOCONIDAE?		
UL	— *Kennatherium shirensis*		

To recapitulate, our proposal to regard the Irdin Manha group of faunas as approximately time equivalent to the middle Eocene of Europe and North America is based on the common presence of *Uintatherium, Palaeosyops, Helaletes, Forstercooperia, Triplopus*?, *Hyrachyus, Eomoropus* and *Miacis* in North America, and *Hyrachyus, Propalaeotherium, Pterodon* and *Propterodon* in Europe, and by the close resemblance existing between various North American brontotheres and amynodonts and certain related Asian species.

The reason for the protracted explanation and justification of our arrangement of the middle Eocene Asian faunas is that it has entailed many changes in previously accepted opinions or concepts. Our view is advanced in the hope that it conforms better to the realities of international correlations.

Less exchange apparently took place in the late Eocene, but *Hyaenodon, Cynodictis* and *Cephalogale* occur also in the late Eocene (Priabonian, or Ludian) of Europe. With the notable exception of the Anthracotheriidae (but no genera occur in common), no families except those containing the three preceding genera are shared by the two continents at this time. Exchange was severely restricted and unbalanced, as indicated by the predominance of carnivorous forms.

From the Uintan C level only *Triplopus* and *Amynodon* occur in common and Wall (1982a)[1] now restricts the latter to North America, invalidating its supposed presence in the Heti fauna. In the Duchesnean Stage a single genus, *Hyaenodon*, is shared with Asian faunas.

As was already remarked by Matthew & Granger (1923b), the closest paleogeographic affinities of the Asiatic early Oligocene are with Europe, not with North America as in the middle Eocene. The following suite of genera occur in common

1 Wall considers that all Asiatic material referred to *Amynodon* should either be placed in *Sharamynodon* or listed as Amynodontidae *incertae sedis*.

Source : MNHN, Paris

in the early Oligocene of Asia and Europe: *Eucricetodon, Hyaenodon, Entelodon, Bothriodon, Lophiomeryx, Ronzotherium,* and perhaps *Eggysodon.* Three genera, *Eucricetodon, Hyaenodon* and *Lophiomeryx,* continue to inhabit both landmasses throughout the Oligocene. *Entelodon* is found also in the middle Oligocene of both. *Bothriodon,* while known only in the early Oligocene of Europe, occurs from early to late in Asia; the contrary is true for *Ronzotherium* (early Oligocene in Asia, early to late in Europe). *Eggysodon* is present in both the early and middle parts of the epoch in Europe and throughout the Oligocene in Asia, if its identification in the early part is confirmed.

The middle Oligocene of Europe and Asia is characterized by a common assemblage that includes *Eucricetodon, Hyaenodon, Entelodon, Lophiomeryx, Eggysodon, Prodremotherium, Schizotherium, Aceratherium* and *Amphicynodon. Schizotherium* persists into the late Oligocene of Asia but not of Europe. *Cadurcotherium* occurs in the European middle Oligocene but is known only in the early and late Oligocene in Asia.

In the late Oligocene the two areas shared *Eucricetodon, Hyaenodon, Entelodon, Lophiomeryx, Prodremotherium, Steneofiber, Cephalogale, Aceratherium, Plesictis, Brachypotherium* and *Amphitragulus.*

The reduction of major marine barriers between the western appendage that is Europe and the main body of the Asian continent is responsible for a freer post-Eocene faunal movement. Paleogeographic obstacles (still mainly marine) remained sufficiently redoubtable, however, to keep the number of genera shared by Europe and Asia in the Oligocene far below that registered during the great exchange between Europe and North America that took place in the early Eocene.

Given the fact that only about half as many genera occurred in both Asia and North America during the Oligocene as were shared by Asia and Europe, restrictions inhibiting dispersal between them were obviously even greater. In the early Oligocene, apart from the ubiquitous *Hyaenodon,* only *Colodon* is present; both are known throughout the Oligocene of the two continents. *Amynodontopsis* is known from the late Eocene of western North America and has been cited in the early Oligocene of Ulan Gochu. Whether this implies that the age given to one or the other occurrence is an error or whether the Asian form is a descendant of the Californian species remains to be decided.

It should be noted that the North American Chadronian is considered to contain a latest Eocene element at its base and to overlap into the middle Oligocene at its summit. Thus, *Agnotocastor,* which appears in the lists earlier in North America than in Asia, is perhaps, in fact, from the latest part of the Chadronian and therefore contemporary. The same could be true for *Prosciurus, Palaeogale* and *Triplopus*?. The Orellan (probably equal to the middle part of the middle Oligocene) contains *Agnotocastor, Prosciurus* and *Palaeogale* in any case in common with the middle Oligocene of Asia, to which must be added *Hyaenodon* and *Colodon,* and perhaps *Palaeocastor.*

The North American Whitneyan Mammal Age apparently straddles the boundary between the middle and late Oligocene. The few genera that it contains in common with Asia are indecisive in correlative value: *Hyaenodon, Colodon* and *Agnotocastor* are both middle and late Oligocene in Asia, and *Prosciurus* does not extend beyond the middle of the epoch on that continent.

The latest Oligocene Arikareean Age shares with the Asian late Oligocene *Hyaenodon* and *Palaeocastor.* It also contains, however, *Prosciurus* and *Palaeogale,* which are not known in Asia beyond the middle Oligocene.

Oligocene faunas seem more homogenous than those of the Paleocene and Eocene. Genera that are shared intercontinentally are not always contemporary; this, and overlapping ranges produce assemblages that possess a characteristic Oligocene stamp but show only slight distinction regarding their temporal situation from early to late in the epoch.

We have kept the basis of our reasoning restricted to genera; a fuller picture admittedly could be drawn if families were taken into consideration, but we believe that the characteristics of rapid spread in terrestrial mammals, coupled with rapid evolutionary change (features that give them their importance in correlative matters) are most concretely translated on the generic level.

Engesser (1979), extolling the virtues of caution with respect to dispersals too hastily visualized, states that such faunas as that of Shand-Gol

Source : MNHN, Paris

and Taben Buluk "contain forms related to European and North American ones (for example, *Cricetops, Parasminthus, Eumys, Amphechinus*, Cylindrodontidae), but they do not furnish any indication of an intercontinental faunal exchange, for they are largely endemic". While we do not entirely accept this conclusion, we share his concern with the persistence of primitive characters, the results of parallel evolution, and the inadequacy of dental remains alone in the identification of forms with morphologically similar teeth. Proving or disproving genetic identity, or even close relationships, on incomplete fossil evidence is practically impossible. This fact is responsible for the problem of data that are sometimes tenuous but which are used, rightly or wrongly, to support hypothesized faunal movements. We recognize the possible uncertainty of identifications and, in consequence, of our correlations and we propose the latter only as what the presently available evidence indicates.

An obvious criticism that can be made of our work is the impression that nearly all of our listed faunas are neatly contained in one of the three divisions, early, middle or late, of each epoch. But certainly no one is more aware than we of the obligatory imprecision and fuzziness of each boundary, especially when proposed on a world wide scale. Correlation, whether it be by marine invertebrates, terrestrial mammals or radioisotopic dates, is still decades away from true precision. We have no illusions as to the accuracy of the terms early, middle and late; they are conventional concepts that express our estimates. The temporal faunal groupings presented here are our version of probability.

It is hoped that our compilation, in this single volume, of the paleobiostratigraphical data on the Paleogene of Asia will serve to facilitate research; we expect, anticipate even, that it will rapidly become outdated by a wealth of new discoveries.

Source : MNHN, Paris

Source : MNHN, Paris

APPENDIX

Biochronologic units based on assemblages of terrestrial fossil mammals are presently in use for the major land masses of the world. In the light of the groupings of faunas we have proposed here, we feel it is appropriate to document a sequence of mammal ages for the Paleogene of Asia.

***

Since the dating and division of the early part of the Paleocene is still uncertain, we will combine the faunas from those formations that are regarded as early or middle Paleocene in a single assemblage. These mammals are taken to characterize the Shanghuan Land Mammal Age of Asia. The faunas that are grouped here are from the Shanghu Fm. (Nanxiong Basin), the Wanghudun Fm. (Qianshan Basin), the Shizikou Fm. (Chijiang Basin), the Fangou Fm. (Shimen Basin), the Gaoyugou Fm. (Tantou Basin), and the Zaoshi Fm. (Chaling Basin).

COMPOSITE SHANGHUAN MAMMALIAN FAUNA

INSECTIVORA
- MICROPTERNODONTIDAE
  - — *Prosarcodon lonanensis*

PANTODONTA
- BEMALAMBDIDAE
  - — *Bemalambda nanhsiungensis*
  - — *Bemalambda pachyoesteus*
  - — *Bemalambda crassus*
  - — *Bemalambda shizikouensis*
  - — *Hypsilolambda chalingensis*
  - — *Hypsilolambda impensa*
- HARPYODIDAE
  - — *Harpyodus euros*
- PASTORALODONTIDAE
  - — *Altilambda pactus*
  - — *Altilambda tenuis*

TILLODONTIA
- TILLOTHERIIDAE
  - — *Lofochaius brachyodus*
  - — *Meiostylodon zaoshiensis*
- TILLODONTIA?
  - — *Dysnoetodon minuta*

ANAGALIDA
- ANAGALIDAE
  - — *Linnania lofoensis*
  - — *Huaiyangale chianshanensis*
  - — *Diacronus anhuiensis*
  - — *Diacronus wanghuensis*
  - — *Wanogale hodungensis*
  - — *Chianshania qianghuaiensis*
  - — *Anaptogale wanghoensis*
  - — *Stenangale xiangensis*

Source : MNHN, Paris

PSEUDICTOPIDAE	— *Anictaps tabiepedis*
	— *Cartictops canina*
	— *Paranictops majuscula*
ASTIGALIDAE	— *Astigale wanensis*
	— *Astigale nanxiangensis*
	— *Zhujegale lirenensis*
	— *Zhujegale jintangensis*
MIXODONTIA	
EURYMYLIDAE	— *Heomys* sp.
MIMOTONIDAE	— *Mimatana wana*
CARNIVORA	
VIVERRAVIDAE	— *Pappictidops orientalis*
	— *Pappictidops acies*
	— *Pappictidops abtusus*
CONDYLARTHRA	
HYOPSODONTIDAE	— *Yuodon protoselenoides*
	— *Palasiadon siurenensis*
	— *Decoredon elangatus*
MESONYCHIDAE	— *Yantanglestes conexus*
	— *Yantanglestes rotundus*
	— *Yantanglestes feiganensis*
	— *Dissacussium shanghoensis*
	— *Hukoutherium ambigum*
	— *Hukoutherium shimenensis*
ORDER INDET.	
ZALAMBDALESTIDAE	— *Anchilestes impolitus*
DIDYMOCONIDAE	— *Zeuctherium niteles*
FAMILY indet.	— *Obtususdon hanhuaensis*

***

Faunas from the following formations are considered representative of the (presumably late Paleocene) Nongshanian Land Mammal Age of Asia: Doumu Fm. (Qianshan Basin), Shuangtasi Fm. (Xuanchang Basin), Nongshan Fm. (Nanxiong Basin), Chijiang and Pinghu Fms. (Chijiang Basin), Nomogen Fm. (Nei Mongol), Taizicun Fm. (Turpan Basin), Khashat Svita at Gashato, and the Zhigden and Naran Mambers of the Naran-Bulak Svita, Nemegt Basin.

The Dazhang and Tantou Fms. of the Tantou Basin have produced fossils that have been tentatively referred to this age but the faunas are still undescribed.

COMPOSITE NONGSHANIAN MAMMALIAN FAUNA

MULTITUBERCULATA	
TAENIOLABIDIDAE	— *Prionessus lucifer*
	— *Sphenopsalis nobiis*
LAMBDOPSALIDAE	— *Lambdopsalis bulla*
INSECTIVORA	
MICROPTERNODONTIDAE	
	— *Sarcodon pygmaeus*
PROTEUTHERA	
FAMILY indet.	— *Praolestes nanus*

Source : MNHN, Paris

PRIMATES?

ADAPIDAE? — *Petrolemur brevirostre*

PANTODONTA

PANTOLAMBDODONTIDAE — *Archaeolambda dayuensis*
— *Archaeolambda tabiensis*
— *Archaeolambda planicanina*
— *Archaeolambda yangtzeensis*
— *Archaeolambda speciosa*
— *Archaeolambda zhuguikengensis*

HARPYODIDAE — *Harpyodus decorus*

PASTORALODONTIDAE — *Altilambda pactus*
— *Altilambda minor*
— *Pastoralodon lacustris*
— *Pastoralodon convexus*
— *Pastoralodon haliutensis*
— *Pastoralodon trofimovi*

CORYPHODONTIDAE — *Coryphodon tsaganensis*

DINOCERATA

UINTATHERIIDAE — *Prodinoceras lacustris*
— *Prodinoceras turfanensis*
— *Prodinoceras diconicus*
— *Prodinoceras martyr*
— *Prodinoceras primigenum*
— *Prodinoceras simplum*

ANAGALIDA

ANAGALIDAE — *Hsiuannania tabiensis*
— *Hsiuannania maguensis*
— *Hsiuannania minor*
— cf. *Huaiyangale leura*
— *Kashanagale zophiae*

PSEUDICTOPIDAE — *Allictops inserrata*
— *Haltictops mirabilis*
— *Haltictops meilingensis*
— *Pseudictops chaii*
— *Pseudictops lophiodon*
— *Pseudictops? tenuis*

FAMILY indet. — *Interogale datangensis*

MIXODONTIA

EURYMYLIDAE — *Eurymylus laticeps*
— *Heomys orientalis*

MIMOTONIDAE — *Mimotona robusta*
— *Mimotona wana*
— *Mimotona borealis*

CREODONTA

OXYAENIDAE — *Oxyaena* sp.

CONDYLARTHRA

PTERYPTICHIDAE — *Pseudanisonchus antelios*

MESONYCHIDAE — *Dissacus magushanensis*
— *Dissacus indigenus*
— *Yantanglestes datangensis*
— *Jiangxia chaotoensis*
— *Pachyaena nemegetica*
— *Plagiocristodon serratus*

Source : MNHN, Paris

CONDYLARTHRA?

PHENACOLOPHIDAE
- — *Minchenella grandis*
- — *Yuelophus validis*
- — *Ganolophus lanikenensis*
- — *Tienshanilophus subashiensis*
- — *Tienshanilophus lianmuqinensis*
- — *Tienshanilophus shengjinkouensis*
- — *Phenacolophus fallax*

EDENTATA?

ERNANODONTIDAE
- — *Ernanodon antelios*

NOTOUNGULATA

ARCTOSTYLOPIDAE
- — *Sinostylops promissus*
- — *Sinostylops progressus*
- — *Asiostylops spanios*
- — *Allostylops periconotus*
- — *Arctostylops iturus*
- — *Arctostylops macrodon*

ORDER INDET.

DIDYMOCONIDAE
- — *Archaeoryctes notialis*

FAMILY indet.
- — *Obtususdon hanhuaensis*
- — *Hyracolestes ermineus*
- — *Wanotherium xuanchengensis*

***

Presently correlated with the early Eocene, the Bumbanian Mammal Age is based on the faunas from the following suite of formations: Zhangshanji Fm. (Laian District), Yuhuangding Fm. (Xichuan Basin), Limuping Fm. (Hengyang Basin), Xinyu Fm. (Yuanshui Basin), Wutu and Niushan Fms. (Changle and Linqu Districts), Dabu and Shisanjianfang Fms. (Turpan Basin), and the Bumban Member of the Naran-Bulak Svita (Nemegt Basin).

Based on inadequate faunal evidence, some formations or parts of formations have been included with doubt in the early Eocene, such as the lower part of the Kuldana Fm. at Barbora, and the unnamed svita at Gashato that furnished *Gomphos*; the lower part of the Subathu Fm. is not cited because of the meager fossil remains it has so far yielded.

COMPOSITE BUMBANIAN MAMMALIAN FAUNA

INSECTIVORA

NYCTITHERIIDAE
- — *Bumbanius rarus*
- — *Oedolius perexiguus*

PROTEUTHERIA

PALAEORYCTIDAE
- — *Naranius infrequens*
- — *Tsaganius ambiguus*

PRIMATES

OMOMYIDAE
- — *Altanius orlovi*

PANTODONTA

PANTOLAMBDODONTIDAE
- — *Archaeolambda* sp.

CORYPHODONTIDAE
- — *Asiocoryphodon conicus*
- — *Asiocoryphodon lophodontus*

Source : MNHN, Paris

	— *"Coryphodon" flerowi*
	— *"Coryphodon" ninchiashanensis*
	— *Coryphodon dabuensis*
DINOCERATA	
Uintatheriidae	— *Phenaceras sinyuensis*
	— *Pyrodon xinjiangensis*
RODENTIA	
Ctenodactylidae	— *Advenimus hupeiensis*
	— *Cocomys lingchaensis*
MIXODONTIA	
Mimotonidae	— *Gomphos elkema*
Eurymylidae	— *Rhombomylus laianensis*
	— *Rhombomylus turpanensis*
	— *Matutinia nitidulus*
CARNIVORA	
Miacidae	— *Miacis tenuis*
CONDYLARTHRA	
Hyopsodontidae	— *Hyopsodus orientalis*
PERISSODACTYLA	
Equidae	— *Hyracotherium gabuniai*
	— *Propachynolophus hengyangensis*
Isectolophidae	— *Homogalax namadicus*
	— *Homogalax wutuensis*
Helaletidae	— *Heptodon niushanensis*
	— *Heptodon tienshanensis*
ARTIODACTYLA	
Dichobunidae	— *Diacodexis pakistanensis*
NOTOUNGULATA	
Arctostylopidae	— *Arctostylops* sp.
	— *Anatolostylops dubius*
ORDER INDET.	
Didymoconidae	— *Hunanictis inexpectatus*
	— *Hsiangolestes youngi*

***

For the Land Mammal Age approximating the middle Eocene we have chosen the fauna of Irdin Manha as representative. Those faunas that we consider correlative are from the following formations: Dongjun Fm. (Bose Basin), Lushi Fm. (Lushi Basin), Lizhuang Fm. (Pingchangguan Basin), Lishigou Fm. (Wucheng Basin), Dacangfang and Hetaoyuan Fms. (Xichuan Basin), Arshanto (and "Tukhum") Fm., Irdin Manha Fm. and Ulan Shireh Fm. (Nei Mongol), Honghe Fm. (Lantian District), Guanzhuang Fm. (Xintai District), Subathu Fm. (Rajauri District), Khaychin Svita (Bugin-Tsav Basin), Kholboldzhi-Nur Svita (Valley of Lakes Depression), Kuldana Fm. (North West Frontier Province), Kolpak Svita (Kazakhstan), Chakpaktas, Obayla and Sargamys Svitas (Zayzan Depression), Alay Svita (Fergana Depression), and the Chonkurchak Svita (Kirghizia).

Formations that have yielded assemblages that could be either Irdinmanhan or Sharamurunian (and hence not included here) are the Chuankou Fm. (Lingbao Basin), Xiangshan Fm. (Lijiang

Source : MNHN, Paris

Basin), Lumeiyi Fm. (Lunan Basin), and the Liankan Fm. (Turpan Basin). Those with assemblages that are probably of Irdinmanhan age but whose contents are too poorly known are the Maojiapo Fm. (Wucheng Basin), Pailoukou Fm. (Yidu District), and the Honglishan and Wulungu Fms. (Junggar Basin).

COMPOSITE IRDINMANHAN MAMMALIAN FAUNA

TAENIODONTA	
Family Indet.	— *Chungchienia sichuanica*
INSECTIVORA	
Family Indet.	— *Seia shahi*
PROTEUTHERIA	
Pantolestidae	— *Bogdia orientalis*
Family Indet.	— *Pakilestes lathrius*
PRIMATES	
Omomyidae	— *Kohatius coppensi*
Family Indet.	— *Lushius qinlinensis*
PANTODONTA	
Pantolambdodontidae	— *Pantolambdodon inermis*
	— *Pantolambdodon bodgensis*
	— *Archaeolambda prima*
Coryphodontidae	— *Eudinoceras mongoliensis*
	— *Eudinoceras xintaiensis*
	— *Eudinoceras crassum*
	— *Eudinoceras youngi*
	— *Eudinoceras kholobolchiensis*
	— *Eudinoceras luminus*
	— *Eudinoceras obailiensis*
	— "*Coryphodon*" *flerowi*
TILLODONTIA	
Tillotheriidae	— *Basalina basalensis*
	— *Kuanchuanius shantunensis*
DINOCERATA	
Uintatheriidae	— *Gobiatherium mirificum*
	— *Uintatherium insperatus*
LAGOMORPHA	
Leporidae	— *Shamolagus grangeri*
	— *Shamolagus ninae*
	— *Lushilagus lohoensis*
RODENTIA	
Paramyidae	— *Abrosomys agasma*
	— *Paramys obaylensis*
Ctenodactylidae	— *Saykanomys chalchae*
	— *Petrokozlovia notos*
	— *Tamquammys tantillus*
	— *Tamquammys wilsoni*
	— *Bolosomys brachybamon*
	— *Geitonomys bouvites*
	— *Birbalomys vandermeuleni*
	— *Birbalomys ijlsti*

Source : MNHN, Paris

— *Birbalomys sondaari*
— *Birbalomys woodi*
— *Chapattimys debruijni*
— *Chapattimys wilsoni*
— *Gumbatomys asifi*
— *Advenimus burkei*
— *Advenimus bohlini*
— *Tsinlingomys youngi*
— *Yuomys weijingensis*
— *Yuomys minggangensis*

PHIOMYIDAE?
FAMILY indet.
— *Bleutosomys dasikerkos*
— *Aksyiromys dalos*
— *Ulkenulastomys abrotos*

CARNIVORA

MIACIDAE
— *Miacis invictis*
— *Miacis lushiensis*

CANIDAE
— *Cynodictis* sp.

CREODONTA

OXYAENIDAE
— *Sarkastodon mongoliensis*
— *Prolaena parva*

HYAENODONTIDAE
— *Paratritemnodon indicus*
— *Propterodon morrisi*
— *Hyaenodon* sp.
— *Pterodon rechetovi*

CONDYLARTHRA

ARCTOCYONIDAE
— *Andrewsarchus mongoliensis*
— *Andrewsarchus crassum*
— *Paratriisodon henanensis*

MESONYCHIDAE
— *Hapalodectes serus*
— *Mesonyx* sp.
— *Pachyaena* sp.
— *Mongolonyx dolichognathus*
— *Mongolonyx robustus*
— *Honanodon hebetis*
— *Honanodon macrodontus*
— *Lohoodon lushiensis*
— *Metahapalodectes makhchinus*

PERISSODACTYLA

BRONTOTHERIIDAE
— *Metatelmatherium parvum*
— *Metatelmatherium cristatum*
— *Microtitan mongoliensis*
— *Arctotitan honghoensis*
— *Acrotitian ulanshirehensis*
— *Gnathotitan berkeyi*
— *Protitan minor*
— *Protitan bellus*
— *Protitan obliquidens*
— *Protitan khaitshinus*
— *Protitan reshetovi*
— *Protitan grangeri*
— *Desmatotitan tukhumensis*
— *Epimanteoceras formosus*
— *Epimanteoceras robustus*
— *Dolichorhinoides angustidens*

Source : MNHN, Paris

	— *Palaeosyops* sp.
	— *Eotitanops dayi*
	— *Pakotitanops latidentatus*
	— *Mulkrajanops moghliensis*
EQUIDAE	— *Propalaeotherium sinense*
	— *Gobihippus menneri*
EOMOROPIDAE	— *Eomoropus* sp.
	— *Litolophus gobiensis*
	— *Grangeria canina*
CHALICOTHERIIDAE	— *Lunania youngi*
ISECTOLOPHIDAE	— *Sastrilophus dehmi*
DEPERETELLIDAE	— *Teleolophus medius*
	— *Teleolophus danjiangensis*
	— *Teleolophus beliajevi*
	— *Diplolophodon* cf. *similis*
	— *Deperetella khaitchinulensis*
	— *Deperetella ferganica*
	— *Deperetella sichuanensis*
	— *Deperetella kungeica*
HELLAETIDAE	— *Helaletes mongoliensis*
	— *Helaletes fissus*
	— *Hyrachyus asiaticus*
	— *Hyrachyus metalophus*
	— *Hyrachyus modestus*?
	— *Colodon* cf. *inceptus*
	— *Veragromovia desmatotheroides*
LOPHIALETIDAE	— *Kalakotia simplicidentata*
	— *Lophialetes expeditus*
	— *Breviodon minutus*
	— *Eoletes gracilis*
	— *Simplaletes sujiensis*
	— *Simplaletes ulanshirehensis*
	— *Schlosseria magister*
	— *Schlosseria hetaoyuanensis*
	— *Zhongjianoletes chowi*
LOPHIALETIDAE?	— *Rhodopagus pygmaeus*
	— *Rhodopagus zdanskyi*
	— *Rhodopagus minimus*
	— *Rhodopagus laiwuensis*
	— *Rhodopagus minutissimus*
	— *Pataecops microdon*
	— *Pataecops parvus*
HYRACODONTIDAE	— *Triplopus kalakotensis*
	— *Triplopus chkhikvadzei*
	— *Triplopus zhukovi*
	— *Triplopus*? *proficiens*
	— *Forstercooperia grandis*
	— *Forstercooperia totadentata*
	— *Prohyracodon* sp.
AMYNODONTIDAE	— *Sharamynodon mongoliensis*
	— *Lushiamynodon sharamurenensis*
	— *Lushiamynodon menchiapuensis*
	— *Lushiamynodon wuchengensis*
	— *Caenolophus minimus*
	— *Sianodon honanensis*

Source : MNHN, Paris

— *Sianodon sinensis*
— *Teilhardia pretiosa*
— *Rostriamynodon grangeri*

ARTIODACTYLA

DICHOBUNIDAE
— *Chorlakkia hassani*
— *Dulcidon gandaensis*
— *Diacodexis pakistanensis*

ANTHRACOTHERIIDAE
— *Anthracokeryx* sp.
— *Anthracothema* sp.

LEPTOMERYCIDAE
— *Archaeomeryx* sp.

RAOELLIDAE
— *Khirtharia dayi*
— *Haqueina haquei*
— *Indohyus indirae*
— *Metkatius kashmiriensis*

HELOHYIDAE
— *Gobiohyus orientalis*
— *Gobiohyus pressidens*
— *Gobiohyus robustus*

FAMILY indet.
— *Askyria oligostus*
— *Paraphenacodus solivagus*
— *Heptaconodon dubium*

PROBOSCIDEA

ANTHRACOBUNIDAE
— *Pilgrimella pilgrimi*
— *Anthracobune pinfoldi*
— *Lammidhania wardi*
— *Jozaria palustris*

ORDER INDET.

DIDYMOCONIDAE
— *Mongoloryctes acutus*

DIDYMOCONIDAE?
— *Kennatherium shirensis*

***

The Sharamurunian Land Mammal Age is based on the fauna of Nei Mongol correlated with the late Eocene. With it are equated the faunas of the following formations: Pondaung Fm. (Mogaung District), Jiyuan Fm. (Jiyuan Basin), Hunshuihe Fm. (Lingbao Basin), Chugouyu Fm. (Lushi Basin), Wulidui Fm. (Wucheng Basin), Shara Murun Fm. (Nei Mongol), Heti Fm. (Yuanqu Basin), Gonosawa Fm. (Hokkaido) and the Uglov Svita (Far East Province).

Some local assemblages cannot be correlated decisively with either late Eocene or early Oligocene faunas. They are retained here apart until the problems attendant upon their stratigraphic origin are resolved, or until sufficient additional material has been collected: Naduo and Gongkang Fms. (Bose and Yongle Basins), Yongning Fm. (Nanning Basin), Shinao Fm. (Shinao Basin), the unnamed svita at Aksoran (Kazakhstan), and the lower part of the Aksyir Svita (Zaysan Basin).

Formations that have yielded too few fossils for adequate dating, although they are considered tentatively as being of Sharamurunian age, are the following: Changxindian Fm. (Beijing), "lower green" fm. (Junggar Basin), Melawi Fm. (Kalimantan), the unnamed deposit at Lahurus (Timor), Ube Fm. (Honshu), Hôsan Fm. (North Korea), the unnamed svita at Alag-Tsav (Mongolia), the Kyzylkain Svita (Zayzan Basin), and the Adigueni Svita (Georgian SSR).

Source : MNHN, Paris

COMPOSITE SHARAMURUNIAN MAMMALIAN FAUNA

INSECTIVORA incertae sedis	— *Ictopidium lechei*
PRIMATES	
Family indet.	— *Hoanghonius stehlini*
	— *Pondaungia cotteri*
	— *Amphipithecus mogaungensis*
TILLODONTIA	
Tillotheriidae	— *Adapidium huanghoensis*
LAGOMORPHA	
Leporidae	— *Shamolagus medius*
	— *Gobiolagus tolmachovi*
Ochotonidae	— *Desmatolagus* sp.
RODENTIA	
Ctenodactylidae	— *Yuomys cavioides*
Dipodidae	— *Parasminthus* sp.
CARNIVORA	
Miacidae	— *Miacis* sp.
Canidae	— *Chailicyon crassidens*
CREODONTA	
Hyaenodontidae	— *Hyaenodon yuanchuensis*
	— *Pterodon* cf. *dakhoensis*
CONDYLARTHRA	
Mesonychidae	— *Honanodon hebetis*
PERISSODACTYLA	
Brontotheriidae	— *Sivatitanops cotteri*
	— *Sivatitanops birmanicum*
	— *Rhinotitan kaiseni*
	— *Rhinotitan mongoliensis*
	— *Rhinotitan orientalis*
	— *Rhinotitan andrewsi*
	— *Pachytitan ajax*
	— *Titanodectes minor*
	— *Titanodectes ingens*
Eomoropidae	— *Eomoropus quadridentatus*
	— *Litolophus major*
Deperetellidae	— *Diplolophodon birmanicum*
	— *Diplolophodon similis*
	— *Deperetella cristata*
	— *Deperetella depereti*
Lophialetidae?	— *Rhodopagus minimus*
Tapiroid Indet.	— *Indolophus guptai*
Hyracodontidae	— *Forstercooperia* sp.
	— *Imequincisoria mazhuangensis*
	— *Imequincisoria micracis*
	— *Juxia borissaiki*
Amynodontidae	— *Lushiamynodon sharamurenensis*
	— *Lushiamynodon obesus*
	— *Sharamynodon mongoliensis*

Source : MNHN, Paris

— *Caenolophus obliquus*
— *Caenolophus promissus*
— *Sianodon ulausuensis*
— *Sianodon chiyuanensis*
— *Sianodon sinensis*
— *Sianodon mienchensis*
— *Paramynodon birmanicus*
— *Paramynodon cotteri*
— *Gigantamynodon promissus*
— *Procadurcodon orientalis*

ARTIODACTYLA

ANTHRACOTHERIIDAE
— *Ulausuodon parvus*
— *Anthracohyus choeroides*
— *Anthracokeryx moriturus*
— *Anthracokeryx birmanicus*
— *Anthracokeryx tenuis*
— *Anthracokeryx dawsoni*
— *Anthracokeryx sinensis*
— *Anthracothema pangan*
— *Anthracothema minima*
— *Anthracothema rubricae*
— *Anthracosenex ambiguus*

LEPTOMERYCIDAE
— *Archaeomeryx optatus*

GELOCIDAE
— *Indomeryx cotteri*
— *Indomeryx arenae*

***

The early Oligocene for us is characterized by the Ergilin-Dzo fauna of Mongolia; it and its correlates constitute the Ergilian Land Mammal Age. The following formations furnished the fossil material: Ulan Gochu Fm., Urtyn Obo Fm. and the Chaganbulage Fm. (Nei Mongol), and the Caijiachong Fm. (Yuezhow Basin).

Those formations whose mammals are probably of Ergilian age but which yielded too little fossil material for accurate correlation are: Houldjin and Baron Sog Fms. (Nei Mongol), Bailuyuan Fm. (Lantian District), Baishuicun Fm. (Yuanqu Basin), the unnamed formation of the Hami Basin, and that of the Luoping Basin, Xiaotun Fm. (Lunan Basin), Ten-neru Fm. (Hokkaido), Iwaki Fm. (Honshu), and the upper part of the Aksyir Svita (Zaysan Basin). Their faunas are not included in the characterizing composite list.

The Kusto Svita of the Zaysan Basin could be either early or middle Oligocene; more material is needed.

COMPOSITE ERGILIAN MAMMALIAN FAUNA

LAGOMORPHA

LEPORIDAE
— *Gobiolagus andrewsi*

OCHOTONIDAE
— *Desmatolagus robustus*
— *Procaprolagus vetustus*

RODENTIA

PARAMYIDAE
— *Hulgana ertnia*

CYLINDRODONTIDAE
— *Ardynomys olseni*
— *Morosomys silentiumis*

Source : MNHN, Paris

CRICETIDAE	— *Eucricetodon* sp.
CTENODACTYLIDAE	— *Karakoromys* sp.
	— *Dianomys obscuratus*
	— *Dianomys qujingensis*
DIPODIDAE	— *Parasminthus* sp.
ANAGALIDA	
ANAGALIDAE	— *Anagale gobiensis*
CARNIVORA	
FELIDAE	— *Nimravus mongoliensis*
CREODONTA	
HYAENODONTIDAE	— *Hyaenodon eminus*
	— *Hyaenodon gigas*
	— *Hyaenodon dubius*
	— *Hyaenodon incertus*
	— *Pterodon mongoliensis*
	— *Pterodon exploratus*
CONDYLARTHRA	
MESONYCHIDAE	— *Mongolestes hadrodens*
PERISSODACTYLA	
BRONTOTHERIIDAE	— *Metatitan progressus*
	— *Metatitan relictus*
	— *Parabrontops gobiensis*
	— *Proembolotherium efremovi*
	— *Embolotherium loucksii*
	— *Embolotherium ergilense*
	— *Embolotherium insigne*
	— *Embolotherium andrewsi*
	— *Embolotherium ultimum*
	— *Epimanteoceras robustum*
CHALICOTHERIIDAE	— *Schizotherium avitum*
DEPERETELLIDAE	— *Teleolophus magnus*
HELALETIDAE	— *Colodon inceptus*
HYRACODONTIDAE	— *Ardynia praecox*
	— *Prohyracodon* sp.
	— *Forstercooperia ergiliinensis*
	— *Urtinotherium incisivum*
	— *Indricotherium parvum*
	— *Indricotherium intermedium*
	— *Indricotherium qujingensis*
RHINOCEROTIDAE	— *Ronzotherium brevirostre*
AMYNODONTIDAE	— *Caenolophus promissus*
	— *Cadurcodon ardynensis*
	— *Gigantamynodon cessator*
	— *Gigantamynodon giganteus*
	— *Cadurcotherium progressus*
	— *Sharamynodon mongoliensis*
	— *Amynodon alxaensis*
	— *Amynodon giganteus*
	— *Amynodontopsis parvidens*
	— *Sianodon* sp.
	— *Paracadurcodon suhaituensis*

Source : MNHN, Paris

ARTIODACTYLA

ENTELODONTIDAE	— *Entelodon gobiensis*
	— *Entelodon orientalis*
	— *Eoentelodon trofimovi*
ANTHRACOTHERIIDAE	— *Bothriogenus hui*
	— *Bothriodon chowi*
LEPTOMERYCIDAE	— *Miomeryx altaicus*
	— *Gobiomeryx dubius*
CERVIDAE	— *Eumeryx* sp.
GELOCIDAE	— *Lophiomeryx angarae*
	— *Lophiomeryx gobiae*

ORDER INDET.

DIDYMOCONIDAE	— *Ardynictis furunculus*

***

No single fauna so well typifies what we regard as the middle Oligocene as that of Shand-Gol in Mongolia. The Shandgolian Land Mammal Age, then, is based on this fauna and those whose correlation appears to be adequately substantiated from the following formations: the unnamed formation at Ulantatal (Jilantai Basin), Wulanbulage Fm., and the Saint-Jacques sediments (Qianlishan District), the unnamed formation at Shuidonggou and the Qinshuiying Fm. (Lingwu District), Beger Svita (Beger-Nur Basin), the unnamed formation at Tsakhir in southern Mongolia, and that at Khatan-Khayrkhan, Narin-Bulak, and Ulan-Ganga in western Mongolia, the Chilikty and Betpakdala Svitas (Kazakhstan), and the lower part of the Aktau Svita (Kazakhstan).

The Buran Svita of the Zaysan Basin could be either middle or late Oligocene, according to the inadequate fossil material. Too little is known from the Kutanbulak Svita near Lake Balkhash for accurate correlation.

COMPOSITE SHANDGOLIAN MAMMALIAN FAUNA

INSECTIVORA

ERINACEIDAE	— *Amphechinus rectus*
	— *Palaeoscaptor acridens*
	— *Tupaiodon morrisi*
SORICIDAE	— *Gobisorex kingae*

LAGOMORPHA

LEPORIDAE	— *Ordolagus teilhardi*
OCHOTONIDAE	— *Desmatolagus gobiensis*
	— *Procaprolagus vetustus*
	— *Procaprolagus radicidens*
	— *Procaprolagus maximus*
	— *Sinolagomys major*
	— *Sinolagomys tatalgolicus*
	— *Bohlinotona pusillus*
	— *Agispelagus simplex*
	— *Ochotonolagus argyropuloi*

RODENTIA

TSAGANOMYIDAE	— *Tsaganomys altaicus*
	— *Cyclomylus lohensis*
	— *Cyclomylus minutus*
	— *Cyclomylus turgaicus*
CYLINDRODONTIDAE	— *Pseudocylindrodon mongolicus*
	— *Ardynomys* sp.

Source : MNHN, Paris

CASTORIDAE	— *Propalaeocastor habilis*
	— *Propalaeocastor kazakhstanicus*
	— *Agnotocastor aubekerovi*
APLODONTIDAE	— *Prosciurus lohiculus*
	— *Prosciurus arboratus*
	— *Plesiospermophilus* sp.
APLODONTIDAE?	— *Selenomys mimicus*
CRICETIDAE	— *Cricetops dormitor*
	— *Cricetops aeneus*
	— *Eucricetodon asiaticus*
	— *Eucricetodon caducus*
TACHYORYCTOIDIDAE	— *Tachyoryctoides obrutschewi*
	— *Tachyoryctoides pachygnathus*
	— *Tachyoryctoides tatalgolicus*
CTENODACTYLIDAE	— *Tataromys sigmodon*
	— *Tataromys plicidens*
	— *Tataromys ulantalalensis*
	— *Tataromys bohlini*
	— *Tataromys deflexus*
	— *Tataromys gobiensis*
	— *Karakaromys decessus*
	— *Leptotataromys gracilidens*
	— *Leptotataromys minor*
	— *Woodomys chelkaris*
	— *Terrarboreus arcanus*
DIPODIDAE	— *Parasminthus tangingoli*
	— *Parasminthus parvulus*
	— *Parasminthus asiaecentralis*
CARNIVORA	
MIACIDAE	— *Amphicticeps shackelfordi*
CANIDAE	— *Cynodictis minor*
	— *Amphicynodon teilhardi*
VIVERRIDAE	— *Palaeoprionodon gracilis*
MUSTELIDAE	— *Palaeogale ulysses*
CREODONTA	
HYAENODONTIDAE	— *Hyaenodon pervagus*
	— *Hyaenodon dubius*
	— *Hyaenodon filholi*
	— *Hyaenodon chunkhtensis*
PERISSODACTYLA	
CHALICOTHERIIDAE	— *Schizotherium turgaicum*
	— *Schizotherium chucuae*
HELALETIDAE	— *Colodon orientalis*
HYRACODONTIDAE	— *Indricotherium brevicervicale*
	— *Indricotherium transouralicum*
	— *Ardynia kazachstanensis*
	— *Paraceratherium* sp.
	— *Aprotodon* sp.
RHINOCEROTIDAE	— *Eggysodon minor*
	— *Eggysodon turgaicus*
	— *Aceratherium* sp.
AMYNODONTIDAE	— *Cadurcodon kazakademius*
	— *Cadurcodon zaisanensis*
	— *Cadurcodon ardynensis*

Source : MNHN, Paris

ARTIODACTYLA

ENTELODONTIDAE
- — *Entelodon diconodon*
- — *Entelodon minor*
- — *Entelodon ordosius*

ANTHRACOTHERIIDAE
- — *Hemimeryx turgaicus*
- — *Brachyodus* sp.
- — *Hyoboops* sp.
- — *Anthracotherium* sp.

LEPTOMERYCIDAE
- — *Miomeryx* sp.
- — *Gobiomeryx dubius*

CERVIDAE
- — *Eumeryx culminus*

SUIDAE
- — *Propalaeochoerus* sp.

GELOCIDAE
- — *Pseudomeryx gobiensis*
- — *Pseudomeryx hypertalonidus*
- — *Prodremotherium flerowi*
- — *Lophiomeryx turgaicus*
- — *Lophiomeryx gobiae*

RUMINANTIA Indet.
- — *Palaeohypsodontus asiaticus*
- — *Hanhaicerus qii*

ORDER INDET.

DIDYMOCONIDAE
- — *Didymoconus colgatei*
- — *Didymoconus berkeyi*

***

The assemblage of Taben Buluk (Gansu) has been chosen for the Tabenbulukian Land Mammal Age and representative of the late Oligocene. Approximate chronologic equivalents have been recovered from the following formations: the unnamed formation at Shargaltein Gol (Gansu), the Yikebulage Fm. (Qianlishan District), the upper part of the Taoshuyuanzi Fm. (Turpan Basin), Askazansor Svita (Kazakhstan), the Aral' Svita (Aral' region of Kazakhstan), and the Pestrotsvet Svita (Georgian SSR).

The "brown" formation (Junggar Basin) is probably contemporary, but little is known from it; lack of fossil mammals makes correlation of the Nura Svita (Zaysan Basin) tenuous, but it has been dated as late Oligocene on other evidence.

The Aktau Svita at Sary-Ozek Station (Kazakhstan) could be either late Oligocene or early Miocene.

COMPOSITE TABENBULUKIAN MAMMALIAN FAUNA

INSECTIVORA

ERINACEIDAE
- — *Palaeoscaptor acridens*
- — *Amphechinus minimus*

LAGOMORPHA

OCHOTONIDAE
- — *Desmatolagus shargaltensis*
- — *Desmatolagus parvidens*
- — *Sinolagomys kansuensis*
- — *Sinolagomys major*
- — *Sinolagomys gracilis*

Source : MNHN, Paris

RODENTIA	
Tsaganomyidae	— *Tsaganomys altaicus*
Castoridae	— *Steneofiber* sp.
	— *Agnotocastor* sp.
Cricetidae	— *Eucricetodon* sp.
	— *Aralomys gigas*
	— *Eumysodon orlovi*
	— *Eumysodon spurius*
	— *Argyromys aralensis*
	— *Argyromys woodi*
	— *Protolactaga borissiaki*
Tachyoryctoididae	— *Tachyoryctoides obrutschewi*
	— *Tachyoryctoides intermedius*
	— *Tachyoryctoides pachygnathus*
	— *Tachyoryctoides kokonorensis*
Ctenodactylidae	— *Tataromys deflexus*
	— *Tataromys sigmodon*
	— *Tataromys grangeri*
	— *Tataromys suni*
	— *Leptotataromys gracilidens*
	— *Yindirtemys woodi*
Dipodidae	— *Parasminthus parvulus*
	— *Parasminthus tangingoli*
	— *Parasminthus asiaecentralis*
CARNIVORA	
Felidae	— *Nimravus* sp.
Amphicyonidae	— *Cephalogale meschethense*
	— *Amphicyon* sp.
Mustelidae	— *Plesictis* sp.
CREODONTA	
Hyaenodontidae	— *Hyaenodon dubius*
PERISSODACTYLA	
Chalicotheriidae	— *Schizotherium chucuae*
	— *Borissiaka betpakdalensis*
Helaletidae	— *Colodon* sp.
Hyracodontidae	— *Aprotodon borissiaki*
	— *Aceratherium aralense*
	— *Paraceratherium prohorovi*
	— *Paraceratherium tienshanensis*
	— *Paraceratherium lipidus*
	— *Protaceratherium* sp.
	— *Benaratherium callistrati*
	— *Indricotherium* sp.
	— *Ardynia plicidentata*
	— *Dzungariotherium turfanensis*
Rhinocerotidae	— *Eggysodon* sp.
	— *Brachypotherium* sp.
	— *Dicerorhinus minutus*
Rhinocerotoidea Indet.	— *Meschotherium meschethicum*
Amynodontidae	— *Cadurcotherium* sp.
ARTIODACTYLA	
Entelodontidae	— *Neoentelodon dzungaricus*
	— *Paraentelodon intermedium*

Source : MNHN, Paris

ANTHRACOTHERIIDAE — *Hemimeryx turgaicus*
— *Anthracotherium kwablianicum*
— *Hyoboops* sp.
— *Bothriodon* sp.
— *Parabrachyodus* cf. *borbonicoides*
— *Telmatodon* sp.
CERVIDAE — *Eumeryx* sp.
SUIDAE — *Conohyus betpakdalensis*
GELOCIDAE — *Lophiomeryx turgaicus*
— *Lophiomeryx benarensis*
— *Prodremotherium trepidus*
— *Miomeryx* sp.
— *Amphitragulus* sp.
TRAGULIDAE — *Iberomeryx parvus*

ORDER INDET.

DIDYMOCONIDAE — *Didymoconus berkeyi*

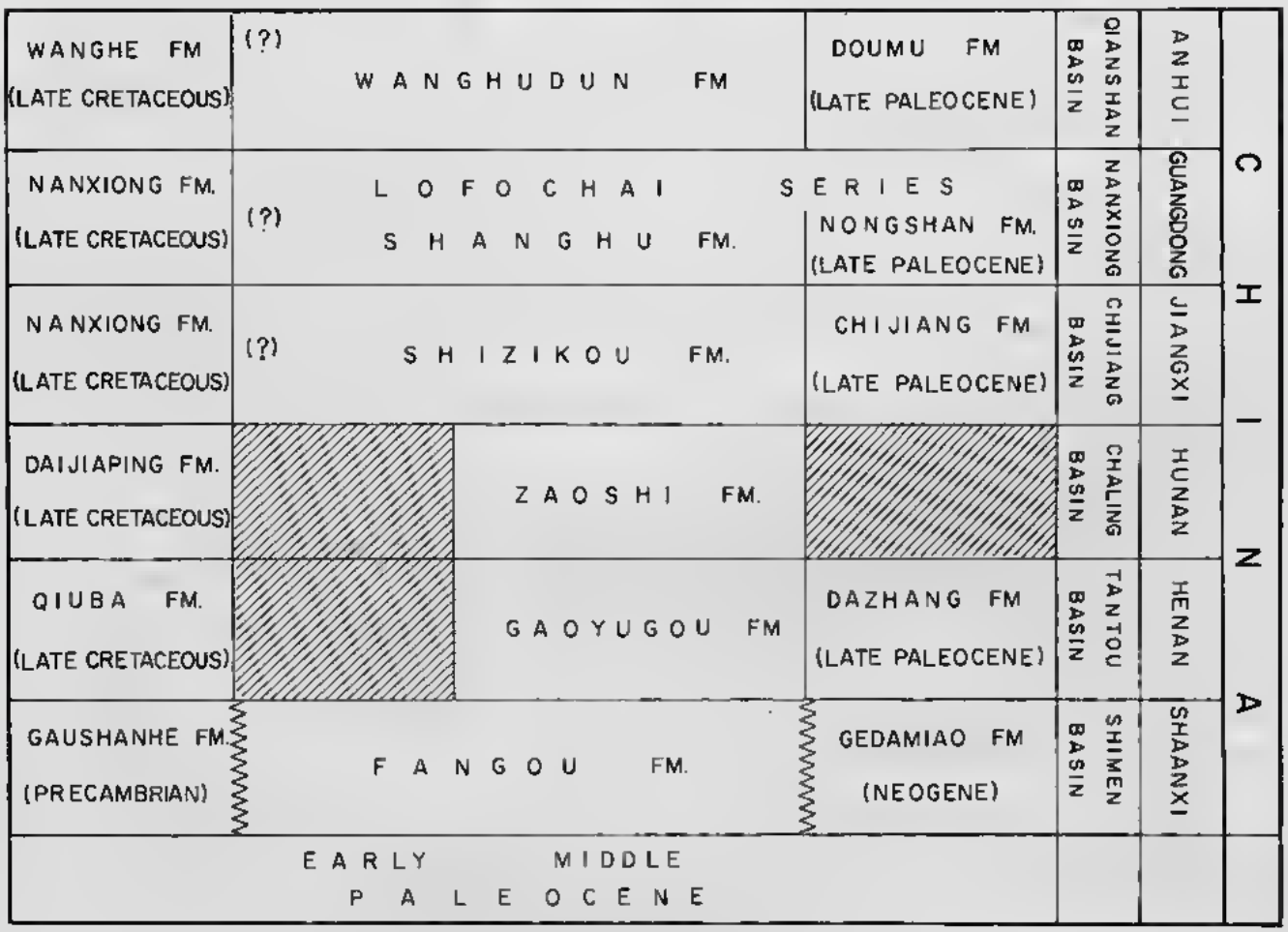


FIG. 224. Geologic formational chart for the early? and middle Paleocene.

Source : MNHN, Paris

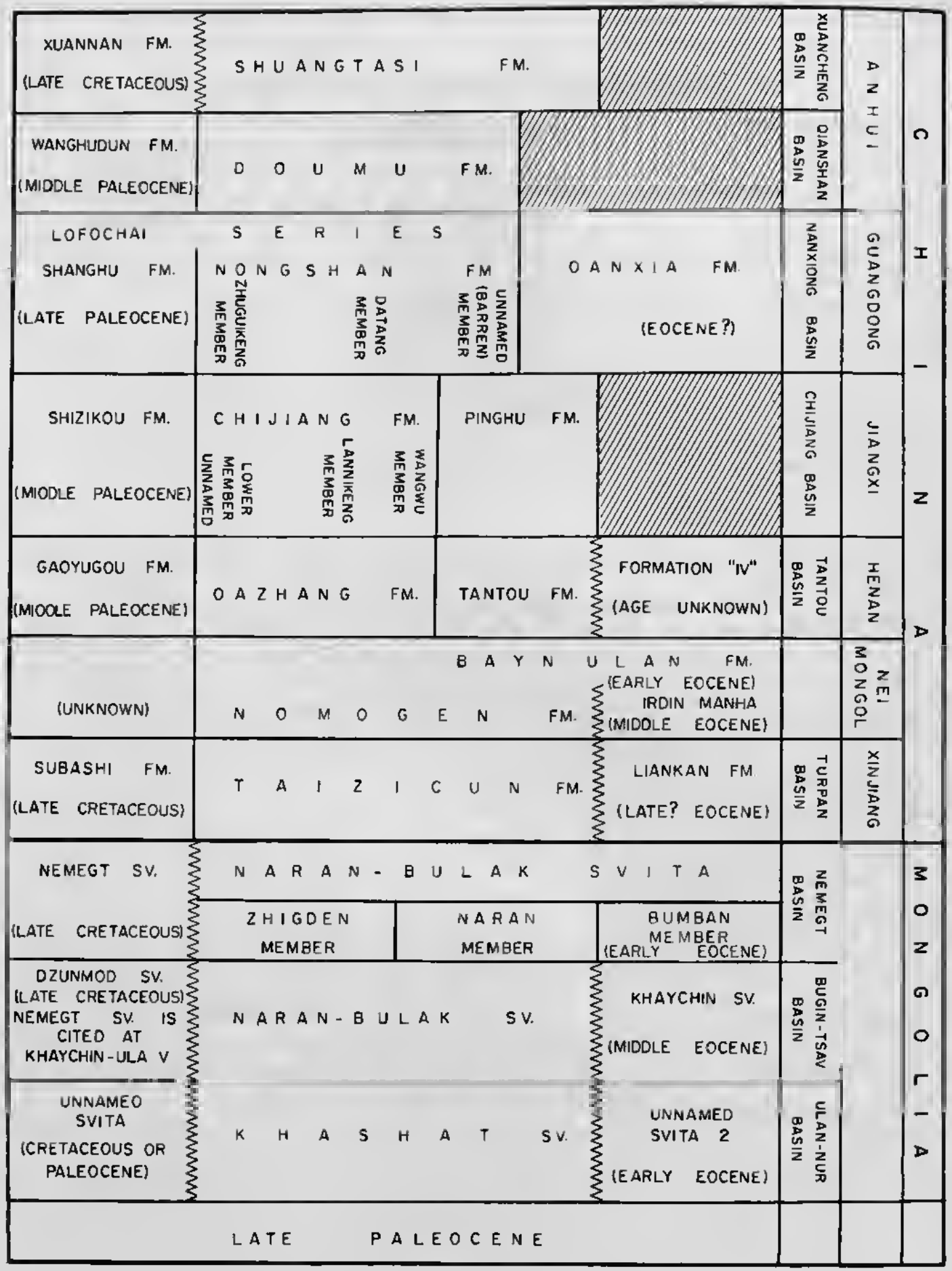


FIG. 225. — Geologic formational chart for the late Paleocene.

Source : MNHN, Paris

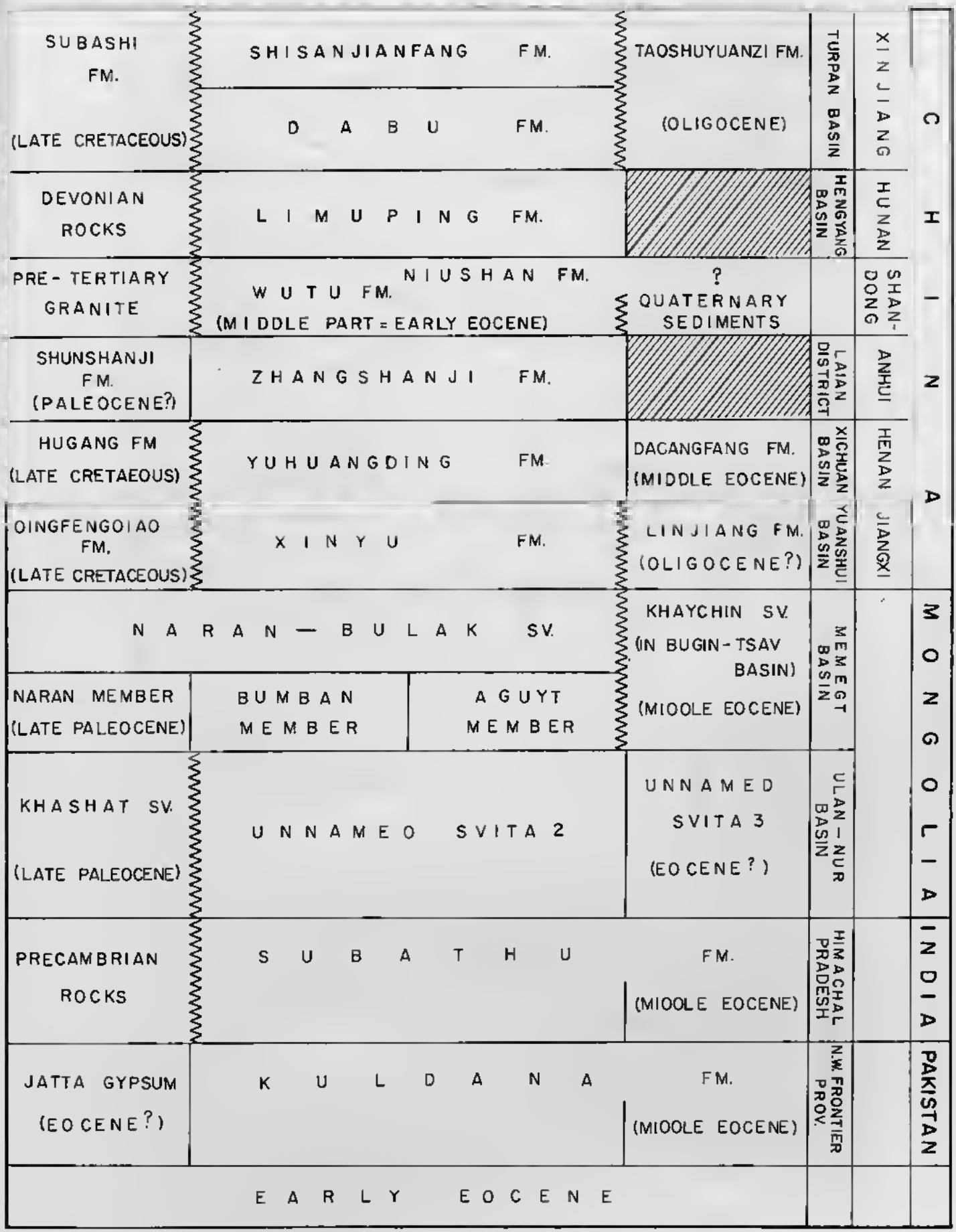


FIG. 226. — Geologic formational chart for the early Eocene.

Source : MNHN, Paris

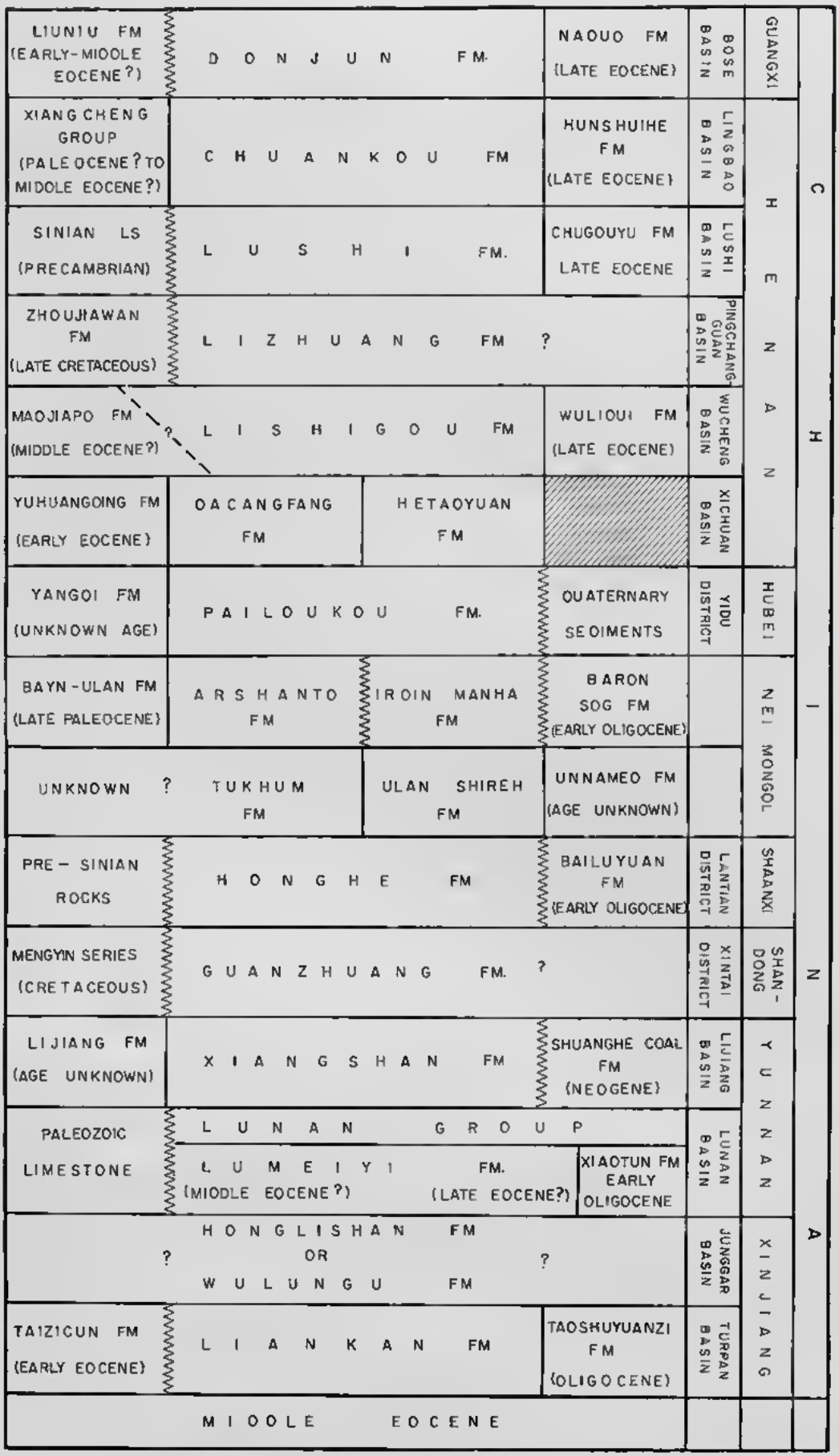


FIG. 227. — Geologic formational chart for the middle Eocene.

Source : MNHN, Paris

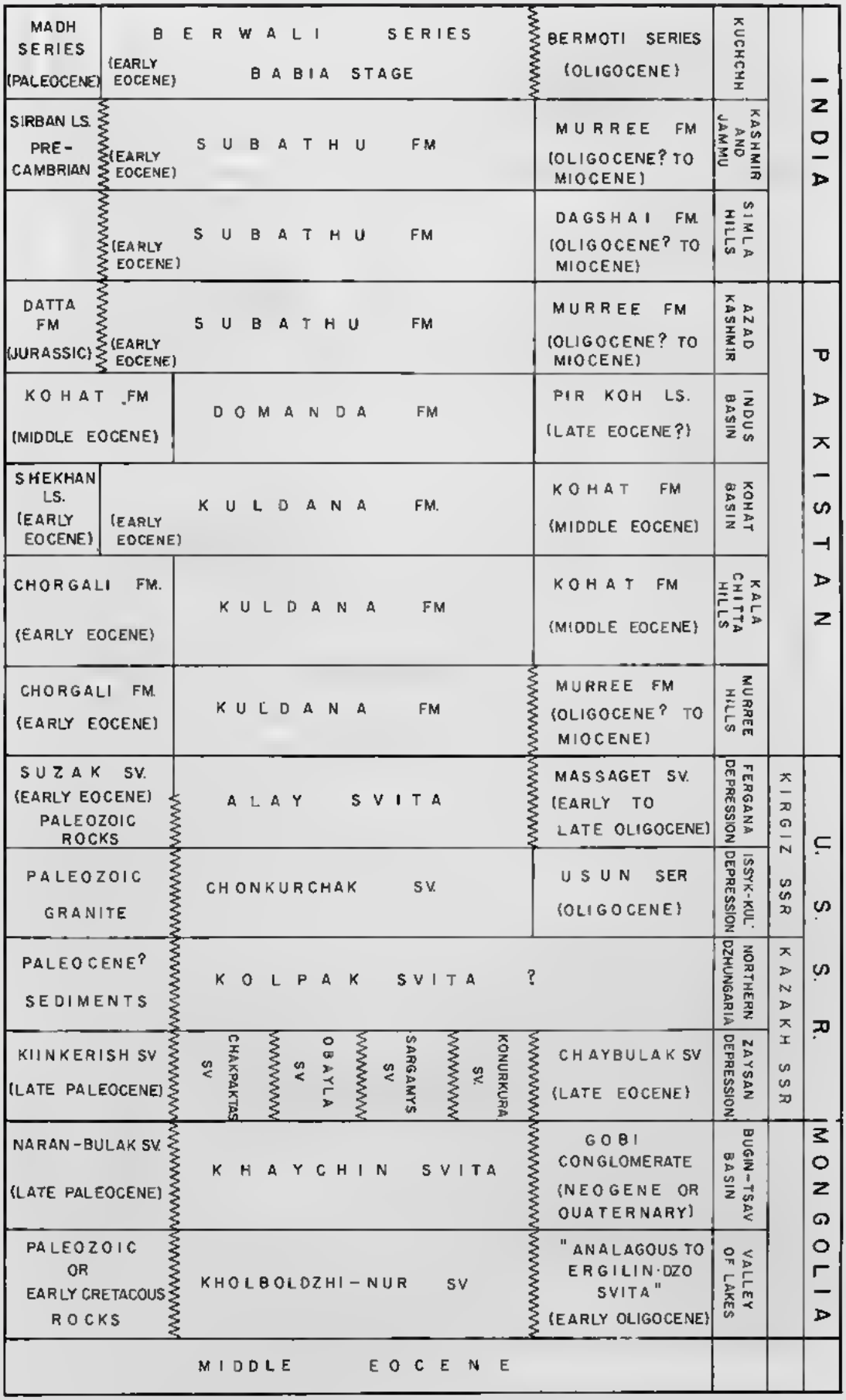


FIG. 227. — Geologic formational chart for the middle Eocene.

Source : MNHN, Paris

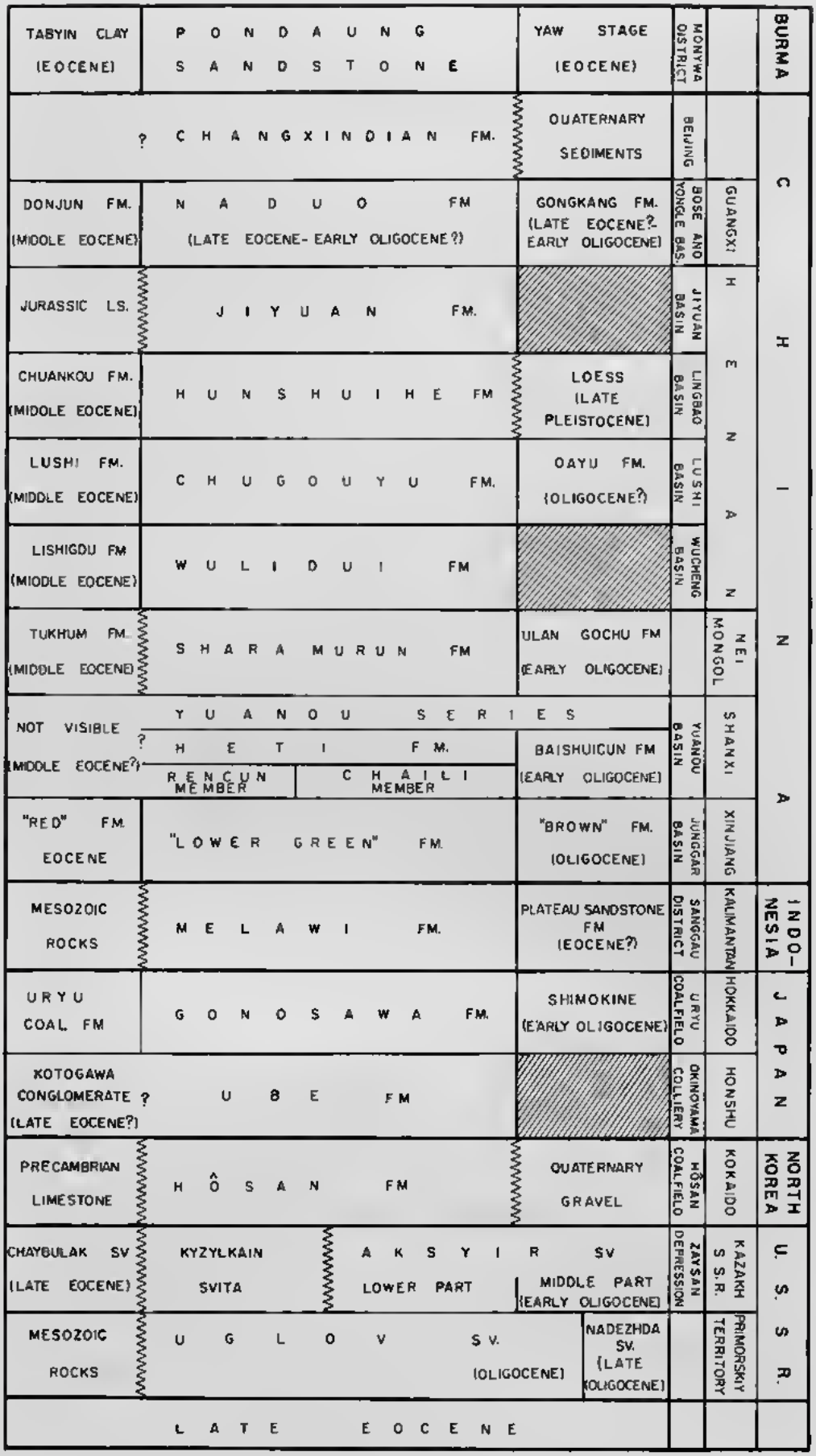


FIG. 228. – Geologic formational chart for the late Eocene.

Source : MNHN, Paris

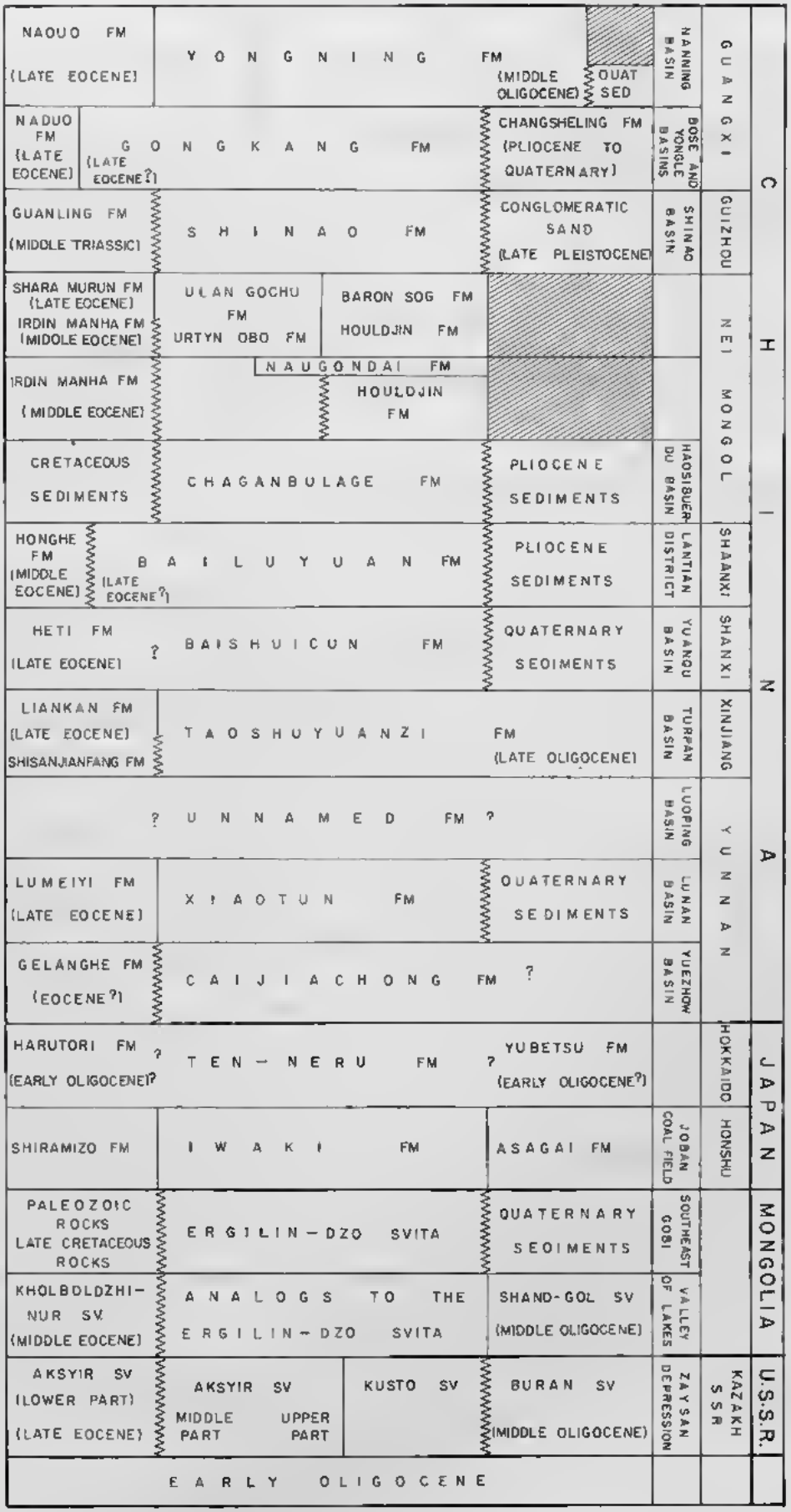


FIG. 229. Geologic formational chart of the early Oligocene.

Source : MNHN, Paris

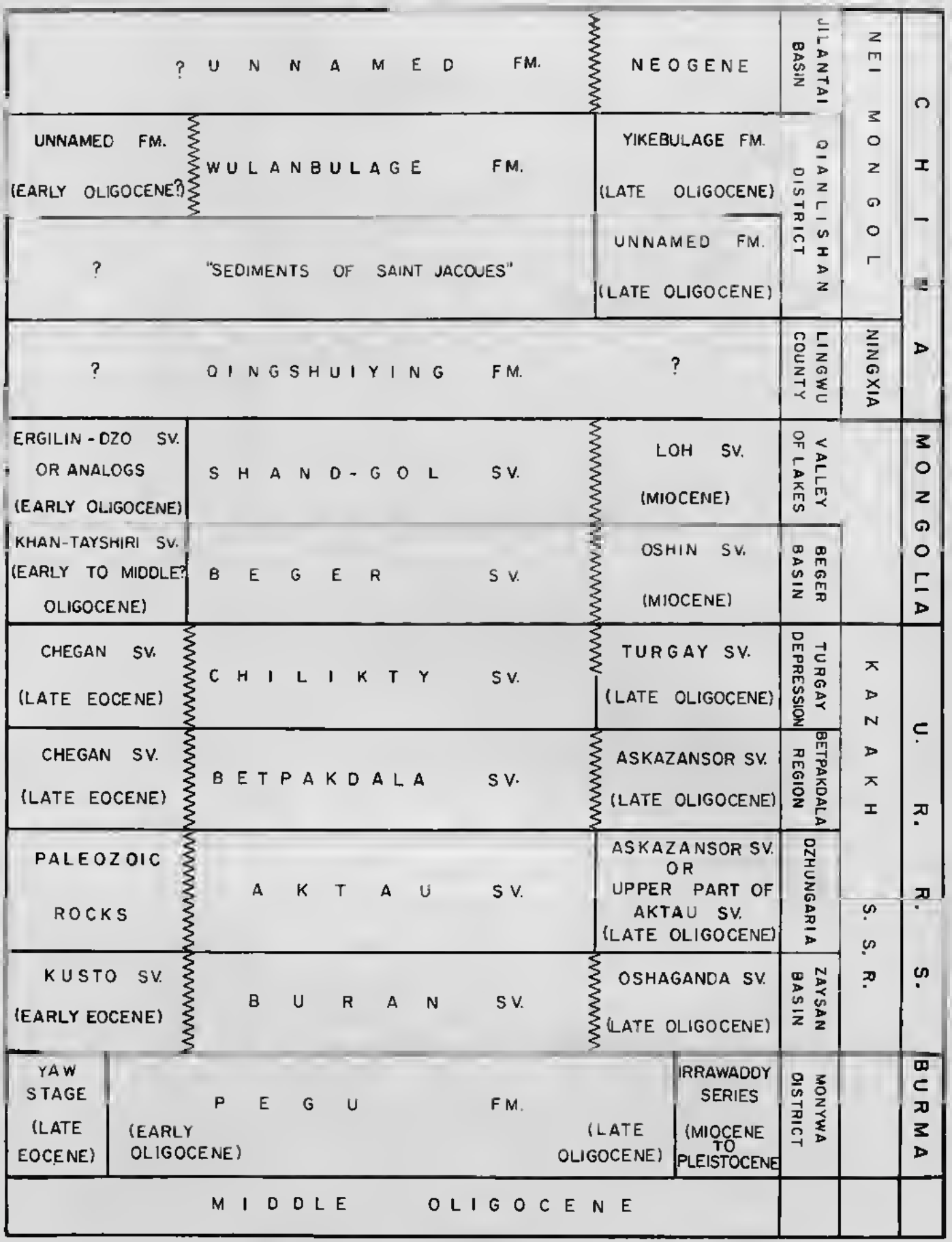


FIG. 230. — Geologic formational chart for the middle Oligocene.

Source : MNHN, Paris

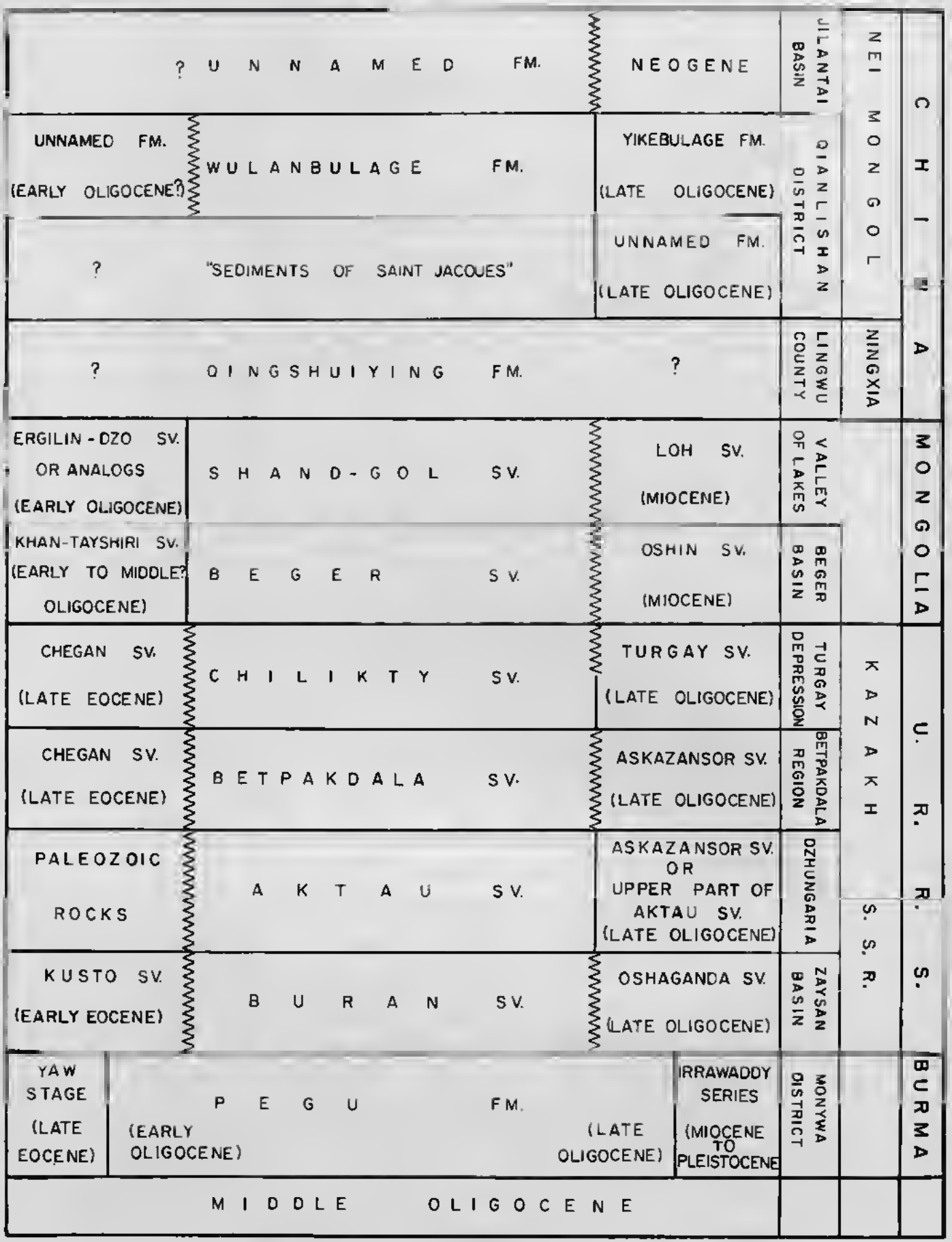


FIG. 230. — Geologic formational chart for the middle Oligocene.

Source : MNHN, Paris

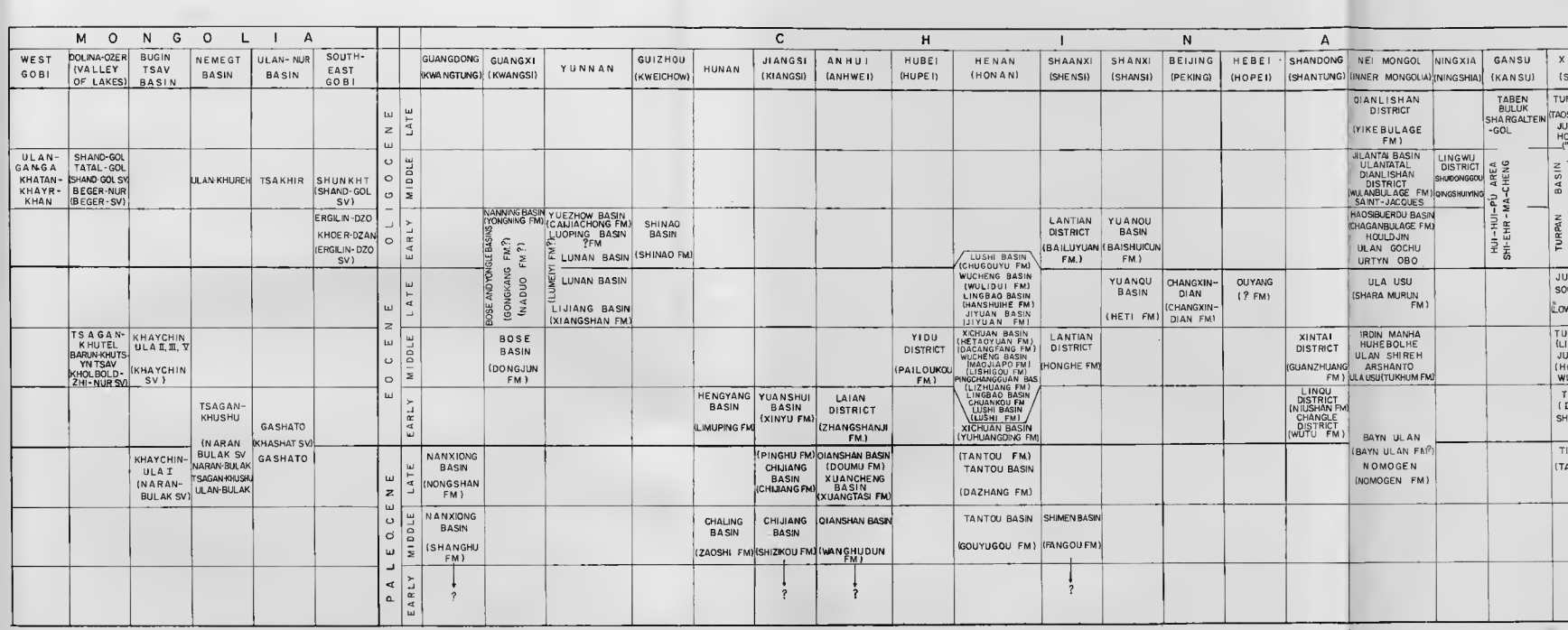


Fig. 232. — Correlation chart of the fossil mam

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Source : MNHN, Paris

| | | |

Source : MNHN, Paris

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